The Wired Scientific City

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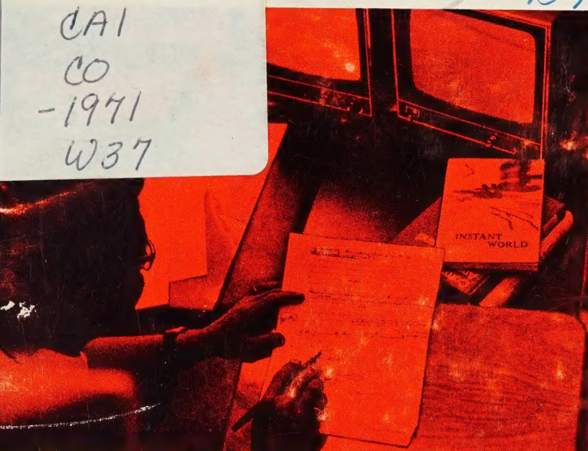

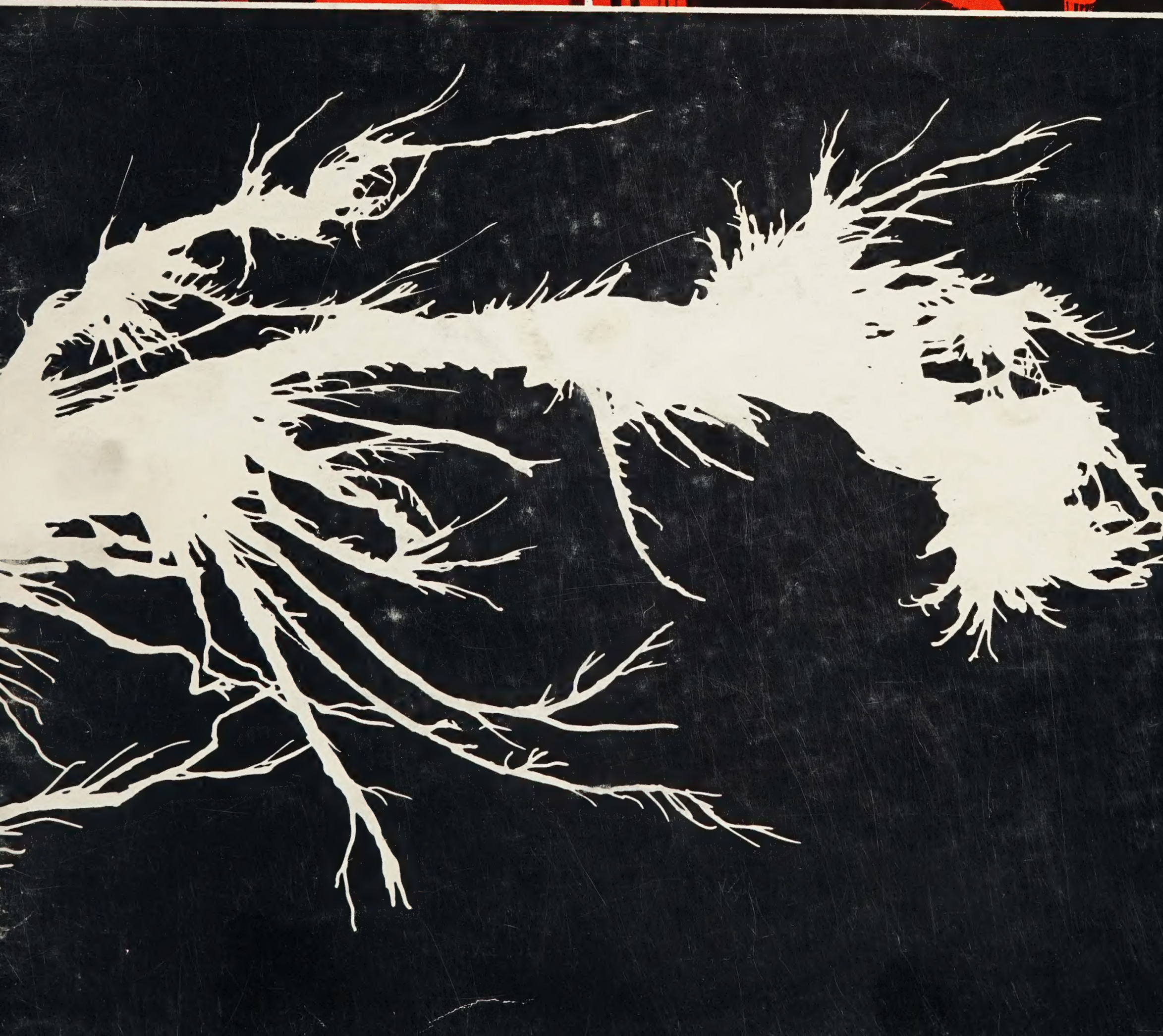

THE WIRED SCIENTIFIC CITY

by

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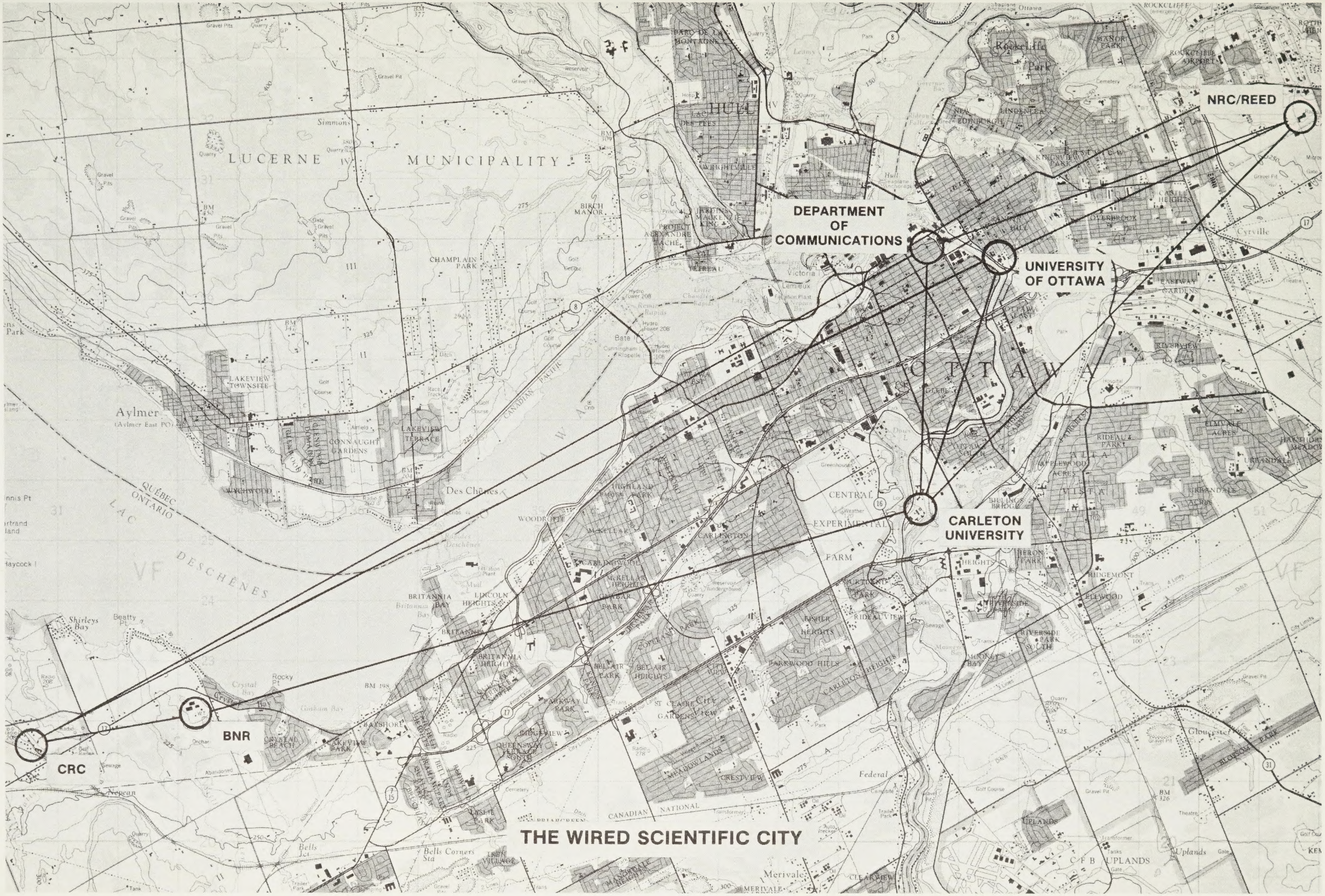
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THE WIRED SCIENTIFIC CITY

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Cover photographs by R. A. Parson

PREFACE

This report presents the results and recommendations of a study conducted by:

Dr. D.A. George, Dean of the Faculty of Engineering,
Dr. B.A. Bowen, Professor of Engineering, and
Dr. D.C. Coll, Associate Professor of Engineering,

of the Systems Engineering Division of the Faculty of Engineering of Carleton University, Ottawa. Contracted by the Department of Communications, Ottawa in Contract OGR1-66, with Dr. J.B. de Mercado, Director of Terrestial Systems and Technology Planning acting as Project Officer. The statement of service to be performed in the contract is:

> "To conduct a study, on behalf of the Department of Communications, Material Management Division, to determine the feasibility of and develop a plan for creating an economical and efficient teaching/research broadband communications network between Ottawa and Carleton Universities and certain Government and Industrial Research establishments in Canada, for the period of April 1, 1971 to October 31, 1971".

For convenient reference purposes, this network is referred to throughout this report as:

"The Wired Scientific City"

and the study was conducted in two phases. Phase I consisted of:

1. a) Survey of potential users and their information requirements, facilities, and potential applications.
   b) Survey of available facilities and systems including common-carrier, and other experiment facilities under development.
   c) Survey of terminal equipment, including television, audio, hard-copy devices, writing tablets, computer graphics, and studio facilities.
2. Definition of the objectives and purposes of a research/teaching network.

A first interim report entitled, "The Wired Scientific City: What, Who, Why", describing progress on phase I was issued on July 31, 1971. The first interim report discussed the definition of the community, the wired scientific city and its uses, available facilities and equipment, and a tentatively proposed system.

Phase II consisted of a study of the communications facilities, and was described in the second interim report, "The Wired Scientific City: Communications Facilities", issued August 31, 1971. The second interim

report described network possibilities and terminal configurations; as well as a basic control algorithm, local system developments, and writing spaces.

This is the final report on the "Wired Scientific City" study contract. The authors hope that with its presentation some small step has been taken towards the rational implementation of the wired city in a manner designed to place the tools of modern technology in the hands of the user, rather than placing the user in the hands of technology.

November, 1971.

B.A.B.
D.C.C.
D.A.G.

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And, of course, the authors are most grateful to their colleagues whose activities are discussed in Chapter 1.

Production of the report owes much to the staff of the Information Office and the Graphics Arts Department of Carleton University, and to Miss Evelyn Irvine who typed numerous drafts and the final copy.

INTRODUCTION

> "Today, foreseeable developments in the technology of telecommunications and computers hold possibilities of a more convenient and satisfying way of life, the satisfaction being measured in spiritual as well as material terms. New and emerging techniques will offer access to information on a scale hitherto unimaginable, together with opportunities for a much wider participation in community affairs and the democratic process."

So began the "Report on Telecommunications in Canada: Instant World",[1] recognizing the potential role of information technology in Canadian affairs, and the concern of the Department of Communications with future development. It is well recognized that communications has always been important to Canada. It has been said that rather than the rails themselves it was the telegraph wires following the railways across the country that in fact bound the nation together. Canada's geography still makes communications one of the determining factors in its national development.

On a broader scale, communications has had a dramatic effect on global society in the past two decades. McLuhan's intuitive descriptions of the influence of the electronic mass media; scholarly literature describing the role of communications in evolution of organizations and societies; and proliferation of communications services available to consumers at all levels, indicate that communications is a dominant factor in the development of society.

Likewise, the computer, since its emergence as a calculator in the early fifties, has had a profound influence on the quality of life styles in the more affluent societies. For example, it has made possible such diverse phenomena as the credit card explosion and spectacular achievements in space, with their associated technologies and new industries.

The widespread availability of computers and broadband communications: the ability to acquire, store, process, and retrieve masses of information quickly has led to an increasing presence in the popular media as well as in scholarly works, of the concept of the "wired city". The "wired city" implies of course far more than access to computer data banks through communications. It includes all services that might be brought to the office or home through broadband cable networks.

Such significant progress is taking place that the implementation of the "wired city", which is commonly understood to imply a universal access to interactive telecommunications:

"capable of transmitting and receiving information in virtually any form",[1]

with

"the means at hand to manipulate and process that information in almost any way and for any purpose",[1]

is an accepted eventuality. In fact, studies show that for almost every example that can be conjectured of a communications/computer information system serving a function of society, at least one operative example is in existence.

The "technological inevitability" of such total communications is not universally accepted without reservation. On one hand, it is just not technically feasible to provide everyone with instantaneous access to all information in almost any form by means of the simple expansion of present concepts and facilities. On the other hand, the growth of computer/communication systems could impose rigid constraints on the development of a free society and on the life styles of the peoples involved. The effects could well be even more pervasive than the sociological effects that TV has had on the present generation, unless steps are taken to discover how the technology can most properly be introduced. As McCarthy has said of computers:[2]

"computers, far from robbing man of his individuality, enable technology to adapt to human diversity",

so communications should provide the user with the capability of communicating with whom or what he chooses for the purposes he desires, with a minimum of predetermined constraints.

Thus, the implications of the "wired city" lead to technical problems that are not yet solved, and which furthermore have ramifications of an economical, sociological, and political nature. The "wired city" must develop in an evolutionary manner; and any successful venture in this area must support and enhance natural communication processes and have the capability to handle users and their requirements which are unknown at the time of its implementation. It is not a "package" that can be offered to the market without proper development.

To introduce the technology of the "wired city" into Canada requires the development of its attributes in a manner suited to Canadian national requirements. However, and inevitably, in the absence of a facility which would permit the correlation of conjecture and experience, discussions of the "wired city" in a Canadian context must be based on hypothesis and extrapolation. Thus, this study presents a proposal for a flexible,

functional, telecommunications system:

i) to provide Canada with first hand experience with the design, operation, use and development of interactive broadband communications; and,

ii) to provide the opportunity to study the effects of this system on the community it serves.

It is proposed to introduce these facilities through a technically aware community that is concerned with the process of communications and the technical functions, so that the successful development of the system and the realization of its potential will not be obscured by the inevitable technical problems.

This system will bring the potential of the "wired city" within the reach of other Canadian users and experimenters in as useful a way as possible, to develop realistic applications of information technology in a Canadian urban environment. It has the further attribute that it is a multiuser, multipurpose facility; an essential requirement in the Canadian economic development.

In order to achieve the goals of the study, it is specifically proposed that broadband telecommunications facilities be installed between Ottawa and Carleton Universities, and certain government and industrial research establishments to form an economical and efficient teaching/research network. The definition of specific activities and experiments to achieve these goals is not a part of this report. Rather, such experimental design is a vital part of the project itself.

The major recommendations resulting from the study are summarized on the following page.

SUMMARY OF RECOMMENDATIONS

It is recommended that a "Wired Scientific City" be established in Ottawa to connect five nodes:

The Department of Communications, in downtown Ottawa.

The Communications Research Centre, located at Shirley's Bay.

Bell-Northern Research, located at Crystal Bay.

Carleton University, on Colonel By Drive.

The University of Ottawa, in Sandy Hill.

Implementation of the required broadband communications facilities should be by means of coaxial cable between the nodes. An independent, non-profit organization is proposed to manage the project, and would have the following structure:

A Board of Directors, responsible for policy.

A Project Office, responsible for operations.

A Program Committee, responsible for the experimental program.

Included would be a full-time staff of nine. The project should be conducted in three phases: decision, implementation, and operation. Several primary tasks must be completed:

Physical implementation of the communications network, terminals, and monitoring and control sub-system.

Design of operating and maintainance procedures.

Development of an operational management system.

Arrangement of appropriate functional uses of the system and design of an experimental program.

Commission of the network and training of operating staff and users.

Operation of the "Wired Scientific City" and conduct of the experimental program.

Primary funding is recommended to be by the federal Department of Communications. It is estimated that $1.5 million will be required, an average of $250,000 for each of the six years of the project.

CHAPTER 1 - THE WIRED SCIENTIFIC CITY

1.1 Introduction

This chapter discusses the rationale for the "Wired Scientific City", and its location in Ottawa; the role of communications in the research/teaching community and the associated functions of the communications network. The chapter provides several specific examples of representative communications that actually occur, in order to demonstrate in general the type of communications the pilot project is designed to enhance.

The idea of the "wired city" has received a great deal of attention in the past several years. It is generally understood as the use of telecommunications for access to information systems. The breadth of the concept ranges from McLuhan's "global village" to the "wide range of broadband communications services that coaxial cable can carry into the home".[3] The immense problems associated with the storage and retrieval of information on a universal basis by the community at large has led to the concept of the "Wired Scientific City": the provision of telecommunication and terminal facilities particularly designed to achieve an enhancement of successful communications within a restricted, yet diverse, technically aware community.

Many feel that the most obvious and immediate requirement for interactive broadband communications exists in the area of business communication particularly in support of managerial functions. While this is unquestionably an important applications area, the number of unsolved problems discussed previously would jeopardize the successful acceptance of the system by the business world unless it is carefully developed. This is, of course, one of the main themes of the "Wired Scientific City" proposal. However, it is felt that if a pilot system is to be successful, both technically and socially, that it must be introduced in an environment in which the primary users can cope with technical difficulties; contribute to its study and development; and assist non-technical users with its experimental use. A rough analogy may be drawn between the way the computer developed from a tool of scientists and engineers to become a mainstay of business data processing, and this approach to the development of advanced, interactive communications into systems which will become of significant value to the community at large.

Many experiments with broadband communications are being conducted throughout the world, for example, the Bell System "Videophone" develop-

ment, cable-TV shopping and metering, the United Kingdom Post Office "Confravision" system, and systems of similar character being tried in various parts of the United States. Interactive educational systems are being used and studied at Stanford, SMU, and Florida and several other universities in the United States. There is a need to gain and acquire this experience in a Canadian context. There are a few Canadian experiments being conducted in this field which provide particular and specialized services, however, no system is attempting to service many needs, some of them quite sophisticated and others relatively elementary, using the same common system. Such a system has distinctly Canadian ramifications, since Canadian systems will probably be multipurpose so that unit costs can be sufficiently low in our environment of low population density and large distances.

Communications equipment which is widely available "off-the-shelf" may be adapted to serve the needs of a pilot network. However, very little of it has been designed with these applications in mind. The "Wired Scientific City", in its wider implications, creates the basis for a new Canadian industry involved in the adaptation of current technology to particular new applications with a potential mass market.

Within the scientific/teaching community in Ottawa are found identifiable requirements for a multipurpose communications system, and a large number of groups concerned professionally with communications. Readily identified components of the community that could be served are:

1) government departments with physically dispersed operational units;
2) two universities engaged in some cooperative teaching, and a widespread demand for post-graduate studies;
3) two research organizations, one private and one public, engaged in the same general area of technology;
4) research groups engaged in research on educational methods and technology;
5) broad and common interest in seminars, e.g. as related to the field of electrical engineering.

Some of the communications activities which could be supported and enhanced through the "Wired Scientific City" are:

1) joint, inter-institutional, seminars;
2) the linking of teaching institutions with each other and off-

campus students, as recommended for study by "The Ring of Iron";[4]

3) joint meetings of small groups of people, working as a committee;
4) close collaborative work between physically separated individuals; provision of a common working space;
5) the expanded opportunity for members of this community to meet together on an informal basis to exchange information, problems, ideas, etc., and to stimulate creativity.

While the members of the Ottawa area are separated by geography, they can be connected by short-haul dedicated communication links. Whereas the experiment would be equally valid for interconnecting any parts of Canada, conducting it in Ottawa in a more limited area will keep the costs of a pilot project much better in hand. It also allows cooperative, experimental use of the network to be better coordinated and observed.

1.2 The Importance of Communications in the Research/Teaching Community

There is a growing awareness within the scientific community of the role that communications plays in both educational and innovative processes, particularly in view of the exponential growth of technical information.

> "The assimilation and dissemination of information by scientists and engineers is an integral part of their research and development activities. With the realization on the part of scientists that they are confronted with an information crisis, much money and effort has gone into research on scientific communication and the development of information retrieval systems. The process by which scientists and engineers disseminate and assimilate information has been studied for a number of years by researchers from a wide variety of disciplines (e.g. psychology, sociology, engineering, history of science)."[5]

As this quotation implies, communication in the scientific community is both a basic concern and the subject of intensive study. The scientific community is often chosen as a subject for study not only because most communications researchers are part of it, but also because the communication within it is considered amenable to study. This is due primarily to the immense number of publications, which may be counted and whose circulation may be traced.

Early research concentrated on the diffusion of information throughout the scientific world via publications. However, more recently:[6]

> "Now we know, thanks to Menzel and Garvey and Griffiths, that if we are speaking of the communication that is used by each research worker as an inspiration and as a data flow that makes his own work possible, then some 80 per cent of that input comes

> to him from other research workers at a stage before formal communication and through the informal channels of the grapevine, the conference, the seminar, the preprint, and the other tentacles of the invisible college."

It is clear that there are two distinct forms of communications in the teaching/research community, the formal and the informal. The formal is characterized by courses and publications, the informal by seminars and interpersonal contact.

Most formal means of communication are reasonably familiar, e.g., journal articles, books, and courses; and the contributions of information technology to the enhancement of this mode are well defined. They include the use of talkback-TV systems in lecture dissemination, computer-aided instruction, and a variety of information retrieval systems. Educational communications in the "Wired Scientific City" are discussed at length in the next section, but it is worth directing attention at this time specifically to the role of information retrieval systems in the communications process. The role that they can play in the "Wired Scientific City" is perhaps best illustrated by part of a list of services suggested for EDUNET, a communication network proposed by EDUCOM, the Interuniversity Communications Council[7], viz:

"(1) Catalogs and directories of bibliographic materials.
(2) Abstracts and full texts of documents.
(3) Directories of on-going research, theses, proposals, grants and contracts.
(4) Directories of existing data banks and computer programmes.
(5) Directories of persons with special knowledge and skills.
(6) Data banks in various fields.
.
.
(9) Current awareness and automatic dissemination services."

Many other services might be added to this list, such as:

1) Self-instructional manuals pertaining to the operation of the system.
2) Cross-referenced, keyworded, indices to standard computer manuals, university catalogs, regulations, and other factual information sources.
3) Current events calendar.
4) Current personnel schedules to allow for meeting scheduling.

While the properties of successful information retrieval systems,[10] those that are flexible and user-oriented, are similar to those proposed for the communications facility of the "Wired Scientific City", it is not

proposed that they be included as features of it. This is due to the amount of research yet to be done and the immense labour involved in any implementation. However, information retrieval is a natural function of the "Wired Scientific City", and a major development activity of many groups within the teaching/research community.* Thus, provision must be made for access to retrieval systems as and when they become available. While anticipating the development of automated systems, it is of interest to consider the present mode of information retrieval in the teaching/research community. Each of the members of the community has access to a variety of libraries that acquire, store, classify, and circulate selected material or citations of material deemed to be of specific interest. Each member receives an immense amount of information directly; most attend many conferences every year; some attend courses and lectures; while most belong to technical societies whose major function is the collection and distribution of relevant information. The sheer bulk of available information implies that only the most dedicated workers are aware of even a small fraction of the material relevant to their area. Unless a specific information search is undertaken, often with the aid of computerized indices, most retrieval occurs haphazardly, and usually on the basis of an informal suggestion from a colleague.

The informal means of communications, it has been noted, are those most relied upon by innovators for the effective transfer of information. Among these other uses of an Inter-University Information Network:

> "sharing of resources, equalizing access to information, accelerating information processing, providing better bibliographic services, improving continuing education, and decreasing administrative delays",

Miller[7] cites "facilitating long-distance interpersonal interactions" as a means of conserving travel time, the sharing of scarce personnel resources, and reducing reaction time in joint work. Menzel[8] has noted six advantages for person-to-person communications in a discussion of "the special functions of informal communications in science". They are:

> "promptness; selective switching (directing queries to the proper source); screening, evaluation, and synthesis; extraction of action implications; transmitting the ineffable; (and) instantaneous feedback."

Another important facet of informal communications is the role played by individuals who Allen[9] has called "technological gatekeepers". The

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* e.g. a system is currently being developed within the Department of Communications.

present study has produced similar observations, viz.,

> "There existed in the organizations...a small number of key people upon whom others relied heavily for information. These key people, or 'technological gatekeepers',...read far more... maintain broader...and longer...relationships with technologists outside of their organizations...mediates between his organizational colleagues and the world outside...effectively couples the organization to scientific and technological activity in the world at large."

Parenthetically, he also points out that these people contribute directly and significantly to the technical program of their organizations.

Another common mode of communications, that is not peculiar to the research/teaching community, is that of the "consultative committee". This is normally a small group whose purpose is consultation, advice, planning, or the solution of a problem of common interest, composed of members of different organizations or divisions of an organization, each of whom represents his own field of expertise. These meetings, which are numerous in the community, tend to follow a distinct pattern which will be present in the use of the "Wired Scientific City". There is an introductory phase, in which the members of the group establish their claim to expertise in the field, defend their preconceived positions, reject the opinions of the others, and misinterpret the purpose of the meeting. This is followed by a second phase in which an understanding of the actual purpose or problem emerges and the participants' requirement for defence of their personal identity* diminishes as their social perception of the others' intentions and thoughts grows.[18] The third phase that can follow is a phase in which solutions to the problem at hand are created through unexpected, synergistic, associations among the members of the group. This synergy, or property of the whole which cannot be derived from knowledge of the component parts, is a feature of cooperative, informal communications that can be enhanced by the "Wired Scientific City".

1.3 Functions of the Communications Facility

It is possible to define three modes in which the communications just discussed will take place in the "Wired Scientific City":

1) The one-to-many mode, with a limited "talkback" capability; to provide for conventional lecture series and seminars.

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* Personal identity in this context is that which is achieved when you believe that others see you as you wish them to.

2) The one-to-one mode, to provide for discussions and working sessions between collaborating individuals, or two small groups.
3) The many-to-many mode, to provide group discussions: to bring all participants into a "common space".

which support the following functions:

1) Lectures and seminars;
2) Collaborations, and resource sharing; and
3) Conferences and discussions.

While this report stresses human-human communications, both man-machine and machine-machine communications will play a significant role in the "Wired City".[10] In the "Wired Scientific City", with its emphasis on the experimental development of suitable facilities and procedures for use by a much wider community than that involved in a pilot project, it goes almost without saying that computer access, aids to communication, control of the network, data transmission, and other automated features will be included in the evolutionary development of the network.

1.3.1 The Educational Function

The first function that the "Wired Scientific City" will allow will be the linking of the universities and the "surrounding community of scholars" via live, interactive, television for teaching purposes: a one-to-many mode with limited feedback capability. The use of television in education is, of course, not new; however,it has been used in many different ways.* These include the broadcast of professionally produced lectures and educational material, the distribution of filmed and video taped spontaneous lectures; and broadcast of live lectures, sometimes with audio talk-back. It is this latter mode which has been selected for the primary educational function of the "Wired Scientific City". Such systems exist in Florida (GENESYS), Texas (TAGER), California (STANFORD),[11] and Minnesota, Wisconsin, Ohio, Rhode Island and Michigan.

The methods of linking teaching institutions with off-campus students in these systems are all based on the concept of bringing the off-campus students 'into' a live lecture with regular on-campus students, by distributing television coverage of the lecture and providing a facility for audio talk-back. In these systems,[12]

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* See, for example, the bibliographical section devoted to Educational TV.

"a fundamental assumption is made that the on-campus environment will be studio classrooms...to get a broad base of support from the faculty, a classroom rather than a studio environment has proven to be essential."

Many methods of transmission are used,[12]

"they fall into two general categories, area coverage systems and point-to-point systems. Area coverage systems include VHF/UHF broadcast TV, CATV, Instructional Television Fixed Service (ITFS), video tape and satellites. Point-to-point systems include common carrier, private microwave, ITFS, and cable. ...talkback systems are all point-to-point systems. There are three common ways in which talkback can be handled; telephone, standard microwave equipment (FM multiplex radio), and ITFS response stations (FM 2.6 GHz radio). ...In all applications one should assume the need for a dedicated service because of the large number of hours of programming, and because dialup telephone service has proven, in practice, to be unsatisfactory.

"University ITV networks will be feasible only with area coverage systems. Because of performance, cost, versatility, channel availability, and privacy, ITFS has to be the most important systems approach to a University ITV network. A survey of University plans throughout the country makes this fact self-evident."

The experience with the TAGER network at SMU in Dallas, Texas has led to the conclusions that,[13]

"The following factors are considered essential to the success thus far enjoyed with instruction via talkback TV at SMU:

1) All classes are 'live', with on-campus students in the room with the professor. No class is offered exclusively via video tape or to only off-campus students.
2) Students at remote receiving classrooms can participate fully in all class discussions.
3) TV cameras are inconspicuous, and there are no operators in the room to distract the professor or the students.
4) Innovations in presentation are possible because of the versatility of the medium.
5) Standards for admission, continuation, and graduation are identical for all students, regardless of geographical location.
6) All homework and examinations are graded on campus, regardless of the students' geographical class locations.
7) Individual consultations with the professor are possible, regardless of student location.

"The system has proved to be a highly satisfactory medium for achieving inter-institutional cooperation in higher education, as well as for bringing opportunities for higher education to industrial employees within a substantial geographical region. In addition, when used imaginatively, talkback TV has proved to be superior to the conventional classroom as an educational medium."

While the quoted articles are heavily in favour of the use of the IFTS microwave band (2.6-3.0 GHz)*, this method is not necessarily most suitable for a multipurpose network.

One educational use to which a system can be put is the counselling function between professor and student, utilizing the full capability of the available communications modes such as a two-way video and facsimile.

The successful experiences in the United States with talkback television systems are in marked contrast to many Canadian experiences, in which the talkback feature was not present or did not function. During recent years, for example, Carleton University has presented many courses on its closed circuit television system. These courses have been broadcast to a number of standard classrooms equipped with TV monitors and nominal talkback via a single telephone in each classroom. Most of the televised courses have been mass attendance freshman courses, some with over 2,000 students. Large scale use has been made of video tape recording, with many repetitions of each lecture throughout each day, placing the onus for discussion on a teaching assistant present in the classroom. These courses have not been considered successful to the same extent that the US ITV courses described above have.

1.3.2 The Seminar Function

The second function that the network will serve is that of linking the universities and the research community via live interactive television for seminar purposes. The term 'seminar' is used here to denote a meeting of a type commonly held in the research/teaching community at which a paper is presented by a single speaker followed by a general discussion. Attendance at such seminars is usually between 10 and 40. This function is similar to that required by instructional television, with the difference that video signals must originate from the node at which the seminar is being held.

Seminars are one of the main means of information exchange in the research community. Some are held at regularly scheduled times, others are presented as and when occasions arise. Speakers may be in-house personnel, or visiting specialists. Topics include brief research reports, visit reports, thesis presentations, paper rehearsals, descriptions of

* In Canada, 23 6MHz channels in the 2548-2686 MHz band. (DOT Standard Radio System Plan 300).

new devices, products, computer programming systems, and so on. Many seminars are regularly advertised (through mailed notices) in the appropriate organizations throughout the community, while others are 'company confidential'. However, our inquiries show that few 'outsiders' attend seminars to which they have been invited, mainly for the reason that travelling to a seminar, the contents of which may turn out to be of little interest, takes too much time from busy schedules. It is also found that many seminars are missed due to insufficient or tardy notices.

Many seminars tend to be similar to formal paper presentations, with little contribution from the audience. While audio talkback allows the remote attendee to participate verbally in discussions, two-way video permits him to readily present graphical inputs, as on a blackboard. This is something that he might well be loath to do if he were physically seated in an audience at a seminar, but which he might do if he could present his input directly.

1.3.3 The Collaboration Function

A third function of the 'wired scientific city' network is the linking of collaborators via two-way visual, audio, and data communications. Such linkages are primarily point-to-point, but could involve more than two stations. This function serves the needs of separated groups or individuals who work together in their professional activities, whether administrative, planning, research oriented or merely consultative.

While the network requirements to satisfy the lecture and seminar functions are fairly well defined, the communications that take place between cooperating groups is more varied, and results in different network requirements. The function to be served here will be illustrated in Section 1.5 by a number of specific examples of existing cooperative programs.

A particularly time-consuming aspect of this type of communications, which would be well served by computer assistance in the "Wired Scientific City", is that of arranging and scheduling meetings.

1.3.4 The Discussion Function

The fourth function that the "Wired Scientific City" must provide for is that of a common communications space in which all nodes on the network are simultaneously connected: a many-to-many node. This function serves the communications requirement for informal group discussions

and provides a milieu for the "lucky accident", or what Buckminster Fuller has termed "synergy", so common to scientific discovery, as well as for satisfactory interpersonal communications in general.

This function implies simultaneous transmission and reception of all communication modes at each node.

This function of the network is the most difficult to describe in terms of specific examples. The role that it plays is scientific communications is apparently so well known and documented that Menzel is led to write:[8]

> "The fact that informal communication plays a very important role in the information exchange of scientists is by now quite well documented and need not be reiterated here."

Certainly, our preliminary studies have confirmed this. As well, the common space, or discussion function provides for an increase in the ease with which "gatekeeper networks" can operate.[9] The preliminary phases of this study had led to the conclusion that information was passed through a network of individuals who travel widely, attend many conferences, and are widely known both socially and professionally through the Ottawa research/teaching network. In fact, these key contact people are well recognized as a vital part of scientific/engineering communications.[9] Observations indicate that they are perhaps even more prominent in universities with their diversities of disciplines.

In relation to discussions, then, the function of the "Wired Scientific City" is twofold:

1) to enhance the natural communication processes by providing technological means for the operation of these processes, and
2) to provide the means whereby the natural process can be expanded through a common discussion space.

As was mentioned above, this function is the most difficult to define because it is a function that is not now available. As McCarthy has said of information technology:[2]

> "The computer will not make its revolutionary impact, however, by doing the old bookkeeping tasks more efficiently. It is finding its way into new applications that will increase human freedom of action. ...it is impossible to recite more than a small fraction of the uses to which enterprising customers will put it."

In an analogous way, communication technology must provide new and different modes of communication, on a formal and informal level. The cost benefits of such modes are not predictable because of the unknown effects they will have on the communities they serve. The only sure

result will be that they will affect those communities, sometimes drastically, as McLuhan has so forcefully demonstrated throughout his writings.

While the provision for the dissemination of lectures and seminars (the one-to-many mode) and facilitation of person-to-person communications (the one-to-one mode) are essentially the automation of existing functions, the common discussion space (the many-to-many mode) is a new function that requires experimental investigation and development before it can be offered as an operational mode of communication and hence, is a vital function of the "Wired Scientific City".

1.4 The Ottawa Research and Teaching Community

Ottawa is the seat of the federal government, the site of two universities, a technological institute, a large industrial research and development establishment, and several engineering firms engaged in developmental work.

The majority of the components of the scientific community are within the federal government, which has some eighty research laboratories and institutes in eleven different departments and agencies. The activities are concentrated in the Departments of Agriculture; Communications, Energy, Mines, and Resources; Health and Welfare; and in the National Research Council. A list of the establishments is given in Table I, which gives an idea of the scope of the activities carried out in the public services. These activities are scattered throughout the Ottawa area and are expanding or moving into Hull. The Department of Agriculture, for example, has the bulk of its laboratories at the Central Experimental Farm on Carling Avenue, but has research stations in the 'green belt' areas southwest of the city. The National Research Council has most of its laboratories at a site on the Montreal Road, where they are spread over a large compound, but also has facilities on Sussex Drive and at Uplands Airport. Similarly, Energy, Mines and Resources is concentrated in a complex of buildings on Booth street, but has activities on the Corkstown Road, on Carling Avenue, and on the Experimental Farm. The point to be made is that the facilities of most Departments are dispersed.

The largest industrial research establishment in the Ottawa area is Bell Canada - Northern Electric Research Limited, with laboratories at Crystal Bay and Kanata. Together with its sister company, Microsystems International Limited, Bell-Northern is engaged in a broad range of

Table I

Research Establishments in the Government of Canada in Ottawa

Agriculture

Animal Diseases Research Institute
Analytical Chemistry Research Service
Engineering Research Service
Statistical Research Service
Animal Research Service
Cell Biology Research Insitute
Entomology Research Institute
Food Research Institute
Ottawa Research Station
Plant Research Institute
Soil Research Institute

Energy, Mines and Resources

Mines Branch
Biological Survey
Earth Physics
Marine Sciences
Inland Waters

Fisheries and Forests

Biometrics
Fisheries Research Board
Canadian Forestry Institutes
- Economics
- Fire
- Management
- Chemical Control
- Forest Products

Health and Welfare

Research and Statistics
Food and Drug
Drug Advisory Bureau
Food Advisory Bureau
Research Laboratories
- Animal Care
- Food
- Microbiology
- Nutrition
- Pharmaceutical Chemistry
- Pharmacology

Health Facilities Design
Health Services
Environmental Health
Canadian Communicable Disease Center

Atomic Energy of Canada, Limited

Commercial Products Division

Communications

Communications Research Centre
National Radio Propagation Lab
National Space Telecommunications Lab
National Communications Lab

Dominion Bureau of Statistics

Indian Affairs and Northern Development

Canadian Wildlife Service
National and Historic Parks
Northern Scientific Research Group

National Defence

Defence Research Board
Defence Research Establishment Ottawa
Defence Research
Operations Research Directorate

National Research Council

Applied Physics
Biology
Building Research
Chemistry
Mechanical Engineering
National Aeronautical Establishment
Physics
Radio and Electrical Engineering

Post Office

Engineering Division

studies in communication technology. Other industrial organizations in Ottawa are Leigh Instruments, Computing Devices of Canada, Acres Intertel, Spartan Aero Services, TMC (Canada), Instronics, and a host of specialized laboratories and consulting firms.

The two universities in Ottawa, Carleton University and the University of Ottawa, have active research/teaching programs in pure and applied science, engineering, and the social sciences.

Special aspects of this research/teaching community are the library and computer facilities available to it. Each of the major institutions has a very extensive scientific and technological library, with large holdings of periodicals, documents, and texts. Primary among Ottawa's library facilities is the National Science Library, which is part of the National Research Council. This is a national library and all others may call on it for assistance. The National Science Library operates a Selective Dissemination of Information (SDI) system to which individuals may subscribe. Another large library system is the Defence Scientific Information Service of the Defence Research Board, which is primarily a document library. Individual research laboratories in the federal system normally have their own libraries as well. The Universities have central and departmental libraries, and are connected to the Ontario Universities' system. All libraries cooperate through established inter-library loan procedures. As yet none of the libraries have automated document retrieval systems, nor automated card indices, but, of course research in information retrieval systems is underway.

The computer facilities in Ottawa may be divided into two categories consisting of those computers that are used in a service bureau or computing centre role, and those that are used as laboratory equipment. The results of a 1970 census of computers in the Ottawa area is shown in Table II. Much activity in the research/teaching community is related to computers: instruction, design, and programming as well as use, so that the computer community forms an integral part of the research/teaching community. In fact, research and teaching in the field of information systems is the basis used in this study for the selection of the stations in a pilot network.

1.5 Functional Examples

It is perhaps easiest to describe who will be the primary users of

Table II

Computers in Ottawa (1970)

MANUFACTURER

	BURR	CDC	DEC	EAI	HON	HP	IBM	UNIVAC	OTHERS	TOTAL
Governmental	5	1	21	2	7	5	28	10	15	94
Industrial	5	1	5	0	2	1	7	11	1	33
Educational	0	4	14	0	1	0	5	0	0	24
										151

the "Wired Scientific City" by providing specific examples, relevant to the functions already described, taken from the Ottawa research/teaching community. These examples will further justify the choice of the functions described in the preceeding sections.

1.5.1 Education

The situation in the Ottawa area as related to graduate studies is very similar to that which exists in the area served by the Stanford Instructional Television Network. Large numbers of part-time students are enrolled as degree candidates at both universities. Table III shows the number of graduate students working for selected employers and studying electrical engineering part-time at Carleton University from 1966 to 1970. Difficulties that universities have had in meeting the demands for continuing education in Science and Engineering have been summarized by Vail and Bush:[13]

> "Logistical problems have loomed large: classes frequently have had to be held at night, when students and faculty are tired; long-distance commuting to class has been necessary for either faculty or students - or both; part-time or adjunct faculty have had to be utilized to teach off-campus or out-of-hours courses."

Part-time students often experience difficulty in attending regularly scheduled on-campus lectures because they cannot afford to be absent from work, or because of occasional travel out-of-town. Thus, the potential participation in regular programs on a part-time basis may be assumed to be much larger than that indicated by the present registration.*

Thus, if the "Wired Scientific City" were to provide the facility for talkback instructional television, with video tape recording as a limited use supplement, it would serve a vitally useful function in the Ottawa research/teaching community, as well as provide a model for interactive educational use in the community at large.

1.5.1.1 IRTV

One example of relevant activities in the communications sub-community vis-a-vis the use of broadband communications in the educational field has been the experimental operation of the Information Retrieval Television (IRTV) system in Ottawa from December 1968 to June 1971.[14]

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*In the 1970/71 academic year, there were 5730 part-time students enrolled in degree credit courses at Carleton University alone.

Table III

A PARTIAL LIST OF PART-TIME GRADUATE STUDENTS
IN ELECTRICAL ENGINEERING AT CARLETON UNIVERSITY
1965-1971.

	ACADEMIC YEAR					
	70-71	69-70	68-69	67-68	66-67	65-66
COMMUNICATIONS RESEARCH CENTRE AND/OR DEFENCE RESEARCH BOARD	8	8	5	5	1	2
DEPARTMENT OF TRANSPORT	6	8	5	3	2	-
NATIONAL RESEARCH COUNCIL	7	10	5	5	3	1
BELL-NORTHERN/ MICROSYSTEMS	27	30	15	14	8	3
NATIONAL DEFENCE	3	4	5	4	4	1
ENERGY, MINES AND RESOURCES	-	1	1	2	1	-
TOTAL	51	61	36	33	19	7

C.A. Billowes of Bell-Northern Research was instrumental in the development of this system which was implemented and operated by Bell Canada for the Ottawa Board of Education. It provided, in individual classrooms, access on demand to a library of some 3,000 video tapes and films. IRTV was eventually installed in five schools, and entered a second phase of development, in which the task of scheduling material and channels was computerized. Mr. Burwell, of the Board of Education, is presently considering the possibility of permanent IRTV for Ottawa schools.

1.5.1.2 Project 91

Mr. C.A. Billowes is part of a group at Bell-Northern Research which is concerned with the development of user-oriented communications. He and Mr. Gordon Johnson, under the leadership of Mr. Alex Curran,[15] Manager of Distribution Systems Engineering, are involved in Project 91 (as well as IRTV, and with many other branches of the Bell Canada System). Project 91 is a part of the Wideband Distribution Systems Study and is a two-way switched video system involving some twelve stations within the Bell-Northern Research/Microsystems International complex at Crystal Bay. Dial telephone circuits are used to control the (manual) video switching and to provide 'Speakerphone' voice communications. The equipment at each station consists of a fixed-view TV camera, an 11-inch monitor, and a 'speakerphone' - equipped telephone. This system is being used for experimental evaluation of the uses of video in conjunction with telephone conversations. Mr. Billowes is being aided in these studies by G.B. Thompson, of Bell-Northern Research, and Professors C.M. Woodside and J.K. Cavers, of the Systems Engineering Division, Carleton University,[21] and Professor D.W. Conrath of Waterloo University.[16] Discussions are currently underway regarding the connection of Project 91 to the Communications Research Centre.

As well, Mr. Johnson's group is concerned with studies of terminal equipment, is developing an experimental television laboratory, and a computer operated voice response unit for IRTV systems.

1.5.1.3 Inter-University Cooperative Teaching

An example of cooperation in the university teaching area that would be well served by a talkback TV network is given by activities in the civil engineering area. During the 1970/71 academic year, some 35 students from Carleton University took 89.431 Hydrology, as a required

course. The course was given at Ottawa University (with their students) and a bus was hired for $300 to transport the Carleton students back and forth. The weekly lectures were consolidated to reduce transportation costs and scheduling problems, and were two hours in length. Talkback television would have allowed the presentation of the cou se in two one-hour lectures per week and effectively reduced the size of the class, thus providing a better learning environment. Also, because travel time would be eliminated, the scheduling o he course would become much simpler. It is often the joint time-tabling of courses that makes their cooperative use impossible, especially if travelling time has to be allowed for.

It is the policy of Carleton and Ottawa Universities to allow all students to take one course each year at the other institution as part of their regular program. This program is in its initial stages and the use of it in 1970/71 was limited; talkback TV could greatly increase the effectiveness of the program, especially for courses in which the main interest is chiefly on one campus or the other.

1.5.1.4 Computer Aided Learning

Another example of the involvement of the communications/computer sub-community in the use of communications in teaching is given by the research and development program of the Information Sciences Section, National Research Council, under the leadership of Mr. W.A. Brown. Some of Mr. Brown's activities are shown schematically in Figure 1.

Mr. Brown himself is actively engaged in several ways with educational technology. He is a member of Project CARTIER, a group from government and industry with interests in education. He is also a member of the NRC Associate Committee on Instructional Technology which has eighteen nationally selected members. This latter body advises on the CAL project; among other functions. Mr. Brown also has frequent contact, on a personal level, with C.A. Billowes regarding IRTV. His group is engaged in the development of computer facilities; software, and terminal devices for Computer Aided Learning (CAL).

The CAL program involves the use of a single central processor (a DEC PDP10) for development of a standardized language for educators, standardized hardware, and the testing of the system by use. It is a national program with participants at the Universities of Calgary, Quebec, New Brunswick, and at the Ontario Institute for Studies in Education.

Links with the Universities of Western Ontario and Alberta also exist, and participation from British Columbia is expected. Communications with the computer takes place over the Government Telephone Service. Communications related to the project is handled at present by an executive committee which meets every two months.

The CAL program includes central computer development, work on peripherals (audio, video, graphical), graphics, and CAL for the handicapped (in cooperation with Dr. Resnick of the Ottawa Civic Hospital).

The Information Sciences Section is well equipped with communications peripherals. They have developed a touch sensitive tablet for computer input, access of audio and video tape recordings under computer control, and various graphical display services. They also make extensive use of VTR of their activities, particularly for demonstration of the system.

The Information Sciences Section is also engaged in radar research: circuitry, microwaves, logic, instrumentation, radio altimetry profiling for the Forestry Service, remote earth sensing with Energy, Mines, and Resources, and the Weather Physics program.

1.5.2 Seminars

As an example of the number of seminars that take place in the Ottawa research/teaching community, some of the seminars in electrical engineering that took place at Carleton University, the University of Ottawa, the Communications Research Centre and Bell-Northern Research from October, 1970 to June, 1971 are shown in Table IV. This chart does not include seminars at the National Research Council, Microsystems, computing centres, other scientific establishments in the area, or those papers presented at relevant conferences in the Ottawa area during this period.* Nor does it include papers presented to professional and scientific associations. While these are normally held in the evening, visiting speakers are usually available during the day for possible seminar presentations.

There appears to be sufficient activity in the research/teaching community in the electrical engineering field alone to occupy a multi-station interactive television channel at least thirty hours per week during most months.

The seminar facility of the "Wired Scientific City" is one that is a

* e.g., the EEMTIC Conference, June 1971 and the NRC Man-Machine Communications Conference, 7 May 1971.

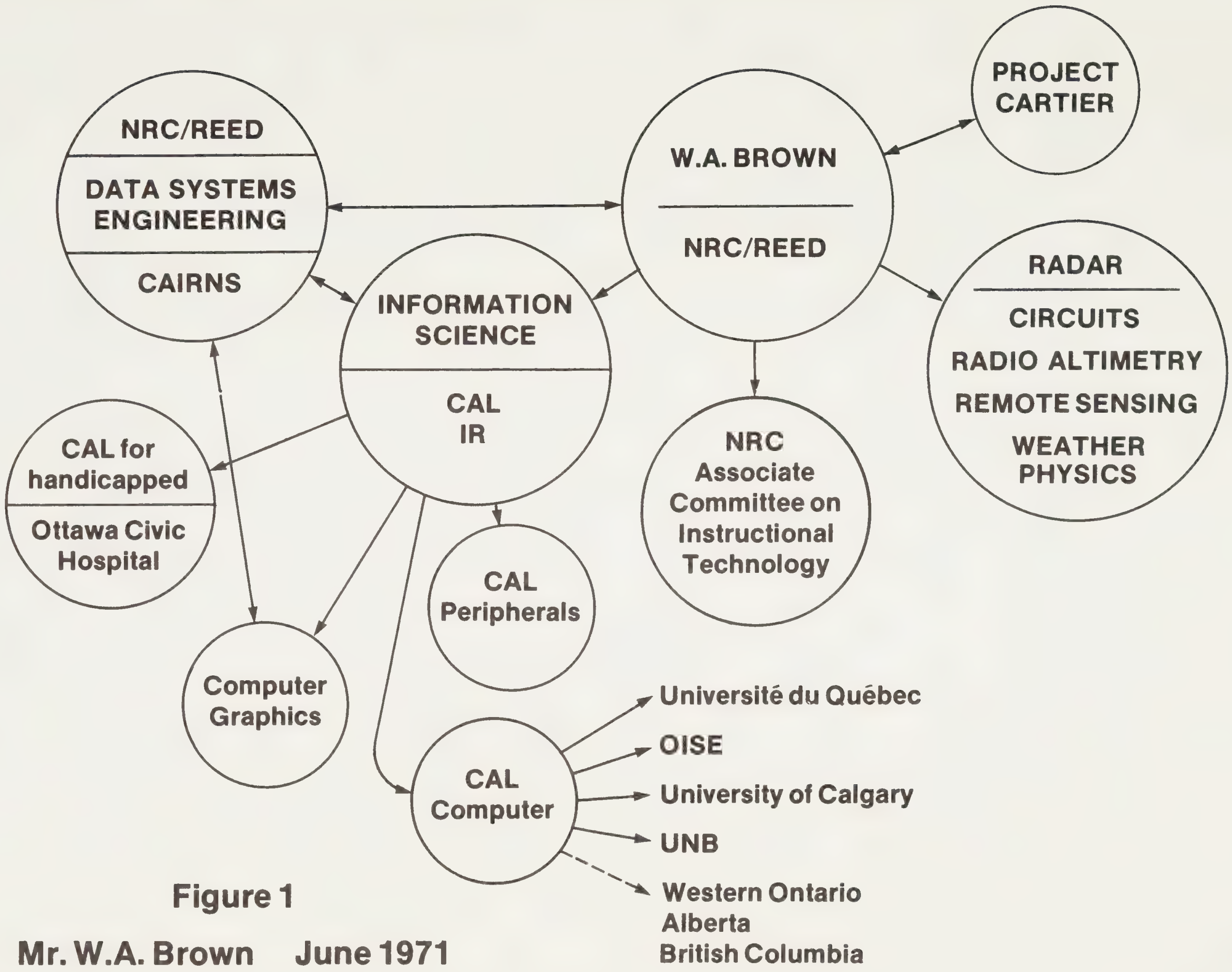


Figure 1

Mr. W.A. Brown June 1971

Table IV

A PARTIAL CALENDAR OF ELECTRICAL ENGINEERING SEMINARS IN THE OTTAWA AREA 1970-1971

		MON	TUES	WED	THURS	FRI
					UO	CU
	4			CU	UO	CU/BNR
OCT	11				UO	CU/BNR
1970	18				UO	CU/BNR
	25	CU			UO	CU/BNR
	1	CU			UO	CU/BNR
NOV	8	CU				BNR
1970	15	CU			UO	CU/BNR
	22	CU			UO	BNR
	29	CU				BNR
	6					BNR
DEC	13					BNR
1970	20					
	27					
	3					BNR
JAN	10	CU			UO	BNR
1971	17	CU			UO	CU/BNR
	24			CRC		BNR
	31	CU			UO	BNR
	7	CU				CU/BNR
FEB	14					BNR
1971	21			CRC	UO	BNR
	28	CU				CU/BNR
	7			CU		BNR
MAR	14	CU		CRC	CRC	BNR
1971	21				CU	CU/BNR
	28	CU			UO	BNR
	4	CRC		CRC		BNR
APR	11					BNR
1971	18					CRC/BNR
	25				CRC	BNR
	2					BNR
MAY	9		CU		CU	BNR
1971	16	CU		CU	CRC	BNR
	23					BNR
	30		CRC			BNR
	6					CU/BNR
JUNE 1971	13				CU/CRC /BNR	CU/CRC /BNR
	20			CU/BNR	CU/BNR	CU/BNR
	27					

CU : CARLETON UNIVERSITY
UO : UNIVERSITY OF OTTAWA
BNR: BELL-NORTHERN RESEARCH
CRC: COMMUNICATIONS RESEARCH CENTRE

general requirement of the research/teaching community, as is the educational facility. They have the following attributes:

1) 'attendance' without the expenditure of travelling time;
2) participation in discussion;
3) sharing of speaker/lecturer costs;
4) recording of presentations for later viewing in case of unavoidable conflicts in scheduling; and
5) maintenance of a universal calendar of events.

1.5.3 Collaboration

This section presents a number of examples of collaborative research in the Ottawa area.

1.5.3.1 Professor V. Makios

The first example is that of Professor V. Makios of Carleton, who has full-time graduate students carrying out their research at the Communications Research Centre, in cooperation with Dr. W. Chidobiak and Dr. G.W. Jull of that establishment. Professor Makios' students are engaged in laboratory research on microwave oscillators, microstrip circuits, and optical materials. He devotes approximately one day a week to visits to CRC to consult with the students and to see the results of their work, the sources of their current problems, and to suggest the next steps to be taken in their research. He also spends a large amount of time on the telephone (one to two hours/week) in consultation with his collaborators. The nature of this cooperative research is such that the supervisor has the need to see experimental work in the laboratory, to establish a close presence with his student, to work on the writing of jointly-authored reports, and to draw sketches and mathematical derivations for his students.

Professor Makios has similar arrangements with Dr. E. Jull, of the National Research Council. There, a graduate student is working on antenna diffraction under Dr. Jull, with Dr. Makios' cooperation. As well, another form of collaboration between Makios and Jull exists in the form of the joint development of graduate courses in electromagnetic theory, which they have been teaching at Carleton for some years, into a new format.

The extent of Professor Makios' cooperative ventures within the research/teaching community are shown schematically in Figure 2. It is evident that his involvement is greater than most, but it is an example

of a function that could readily be enhanced by the "Wired Scientific City".

1.5.3.2 Professor A.R. Boothroyd

Another example of cooperative research in the electrical engineering community exists between Professor A.R. Boothroyd, Chairman of the Electronics and Materials Division of the Faculty of Engineering at Carleton University, and his colleagues (particularly Professor M.A. Copeland) and P. Nichols and G. Sadler of Bell-Northern Research. The cooperation is in the area of solid state devices: basic device theory, device modelling, and computer aided circuit analysis. To a large extent, Professor Boothroyd and his students use facilities at Bell-Northern Research for device fabrication and measurement. They also use computer facilities there. While access to the Bell-Northern Research computer can be gained from a local terminal at Carleton, the users prefer to use a terminal at Bell-Northern Research, because of the ease of communications with computer personnel there. Professor Copeland also has students working at Bell-Northern Research and Bell-Northern Research personnel use device fabrication facilities at Carleton.

Professor Boothroyd visits Bell-Northern Research on a regular basis, for about one day per week. His rationale for doing so is to obtain a change of environment, stimulation through contact with his colleagues at Bell-Northern Research, and to escape the (anticipated) interruptions that are prevalent in his situation within the University. Professor Boothroyd has many extra-territorial communications: he has been a member of an IEEE committee on devices and solid state circuits for six years, and visits regularly at IBM, BTL, and Berkeley.

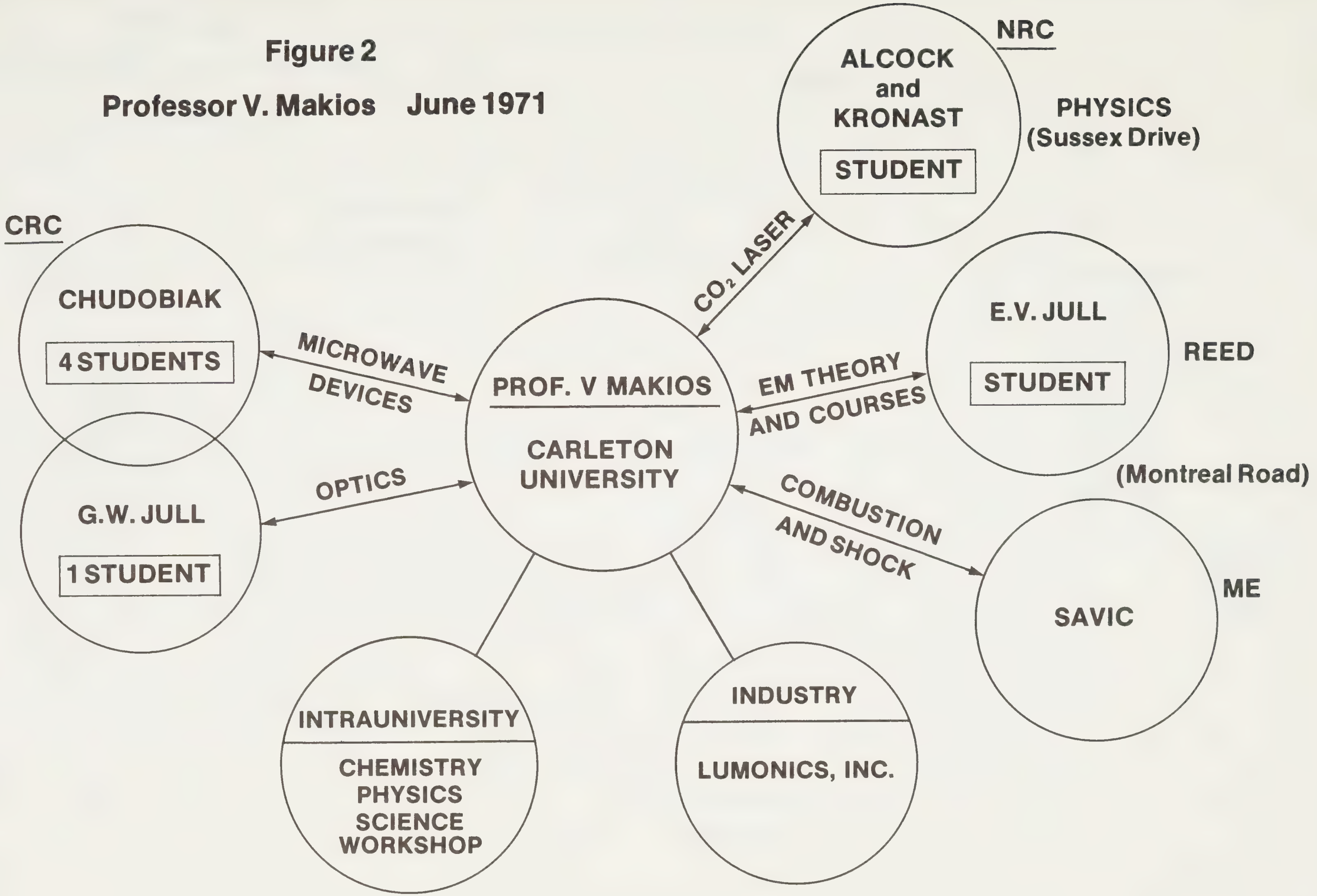
The communication requirements associated with this cooperative activity are for support of personnel using physical facilities remote from their normal place of work.

1.5.3.3 Low Energy Nuclear Physics

A further example of scientists cooperating and sharing common resources is given by the activity in low energy nuclear physics at Carleton and Ottawa Universities, and the Applied Physics Section of the National Research Council. This research is based on the joint use of the Dynamatron accelerator at NRC, and a DEC PDP9 computer at the Dynamatron. The communication paths in this network are shown in Figure 3. The

Figure 2

Professor V. Makios June 1971



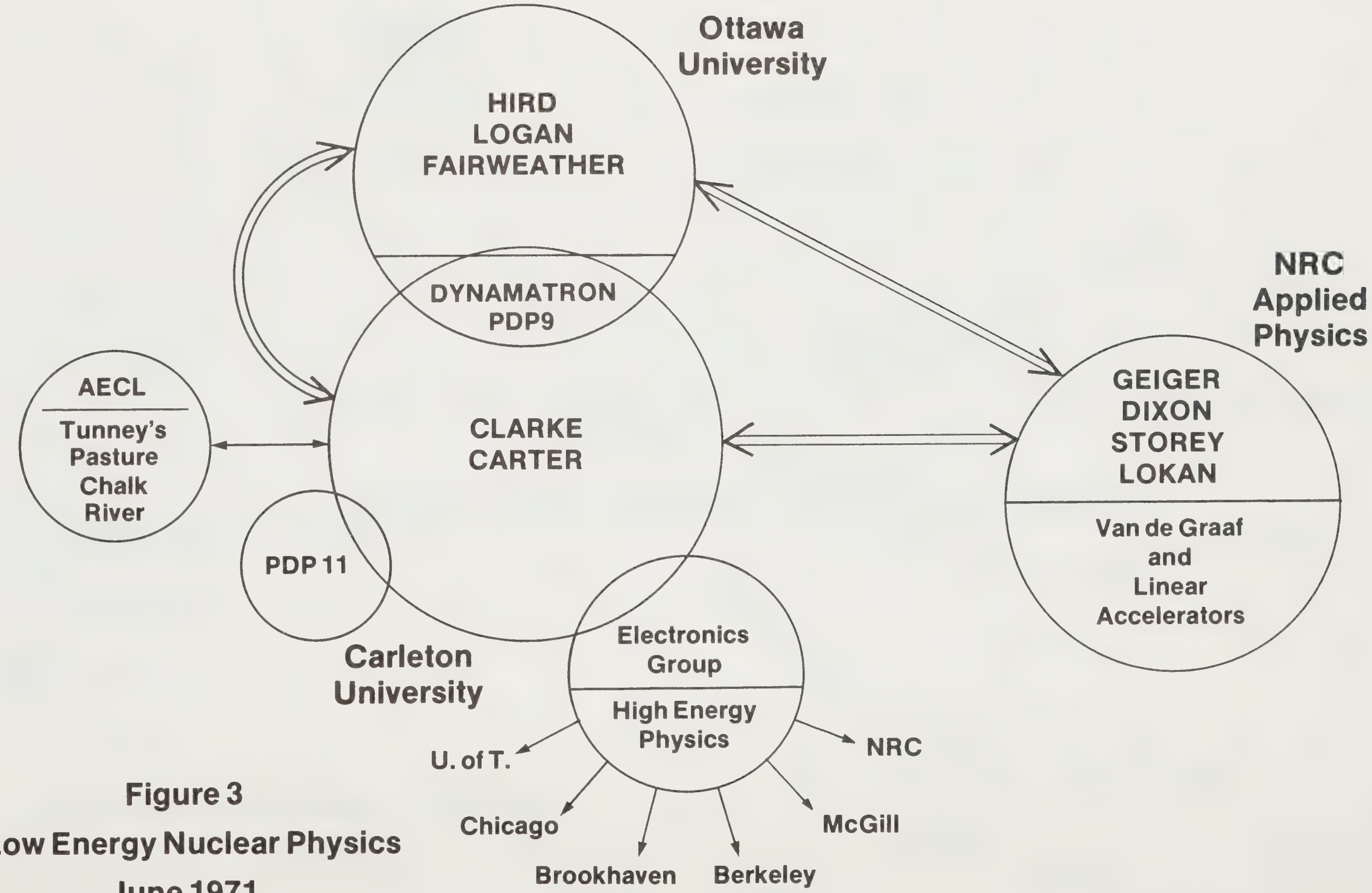


Figure 3
Low Energy Nuclear Physics
June 1971

members of this community write jointly-authored research papers and, hence, have a great deal of personal contact at times. One major communications requirement is for data transmission between measurement apparatus (nuclear scalers) and central computers, e.g. the SIGMA 7 at Carleton. As an aside, the Physics Department at Carleton University has made an attempt to overcome a serious problem in interpersonal telecommunications, viz., that of contacting people. They have installed a "message alert" system through which the fact that messages exist for any staff member is shown on annunciators mounted in the hallways of their building.

1.5.3.4 Software Development

An example, which requires the use of a common writing space, is given by the activities of an informal group formed by computer scientists in the Ottawa area to consider the development of 'compiler generators'. This group includes G. Scott of Bell-Northern Research, D.A. Thomas of Carleton University, and others from the Dominion Bureau of Statistics, Ottawa University, and the National Research Council. A major activity of this group is the joint development of computer programs, which involves a great deal of working on program listings on a line-by-line basis, that is similar to editing.

1.5.3.5 BioMedical Engineering

A cooperative program involving Professors B. Pagurek and J.S.Riordon of Carleton University and their graduate students with Dr. McKendry of the Ottawa Civic Hospital has recently been brought to a successful conclusion. This project involved the use of data communications to connect a computer at Carleton with an automatic blood analyzer and infusion pumps at the Civic Hospital to affect real-time control of the blood sugar levels in 'in vivo' subjects accurately for extended periods of time. This project not only solved a complex control engineering problem but also overcame many of the practical difficulties of conducting experments when the equipment is not all in one location.

As a result of this project, preliminary discussions of a much more ambitious undertaking are being held, viz., the automatic treatment of patients in diabetic coma. This project would involve physicians, medical scientists, control engineers, and communications/computer engineers in Toronto, Guelph, at the University of Ottawa, Carleton University and the Ottawa Civic Hospital. The entire project depends upon the

existence of communications. During the experimental phases, it is obvious that effective communications is necessary between the various groups involved. While the control engineers are faced with a very complex multiple-input, multiple-output problem, which in itself will be difficult to solve, synthesis of a solution will rely on the teleprocessing of experimental data, and ultimate implementation of automatic treatment will rely on teleprocessing of real-time data. However, most importantly, if this project reaches an actual treatment stage, the clinician in charge of the treatment must have the same degree of control over his team and their equipment as he would have if he and they were all together in the same room. Not only that, he must have complete information regarding the progress of the treatment available to him in a meaningful form at all times, and the communications/information/control system must be designed so that he has confidence that he is, in fact, in complete control of the treatment. This is surely the "Wired Scientific City".

1.5.3.6 Remote Resource Sharing

Professors L.R. Morris, of the Systems Engineering Division, J.P. Paillet of the Linguistics Department, and A. Moffit of the Psychology Department at Carleton University are cooperating in a joint research program in speech processing. A PDP15 computer in the Engineering building is to be operated remotely from the Child Psychology laboratory to gather data on child speech recognition. During these experiments, video communications will be provided over Carleton's internal coaxial cable system to allow the remote operator to visually verify computer functioning and to observe the computer's graphic terminal.*

1.5.3.7 Management Information Systems Development

At the initiative of Mr. Peter Nador of Bell-Northern Research, representatives of several different organizations have been meeting informally in Ottawa to discuss design problems in management information systems. At present, an active program in design methodology is being formulated by Mr. Nador and Mr. E.W. Chadler of Bell-Northern Research and Professors J.S. Riordon, Chairman of Systems Engineering and A. Guthrie of the School of Commerce, Carleton University. This group of diverse individuals, together with specialists in computer science, are not only potential users of the "Wired Scientific City"

* Computer resource sharing is the subject of the Canadian University Computer Network (CANUNET) study being carried out for Department of Communications.

but their work is directly related to the detailed design of it. Since the network is essentially a general information system, both information systems which are integral to it and its functional automation could well reflect the results of their research.

1.6 Experimental Applications

The functional applications of the "Wired Scientific City": lectures, seminars, conferences, and discussions, have been discussed at some length in the previous sections. Their initial use in the pilot network will, of course, be experimental. The technical facilities, modes of presentation, and user attitudes and reaction are all areas which can be studied and developed.

The facilities of the "Wired Scientific City", with its flexibility and complement of basic terminals, is suitable for experimental operation of such two-way services as[3]:

a) household services: security, surveillance and alarm; banking at home; shopping at home; in-house printout of newspaper and other data; electronic mail delivery; special interest programs played on order; and opinion polling.

b) business: data retrieval; computer time-sharing; document reproduction; remote meter reading; market testing; and credit-card validation.

c) education: computer-aided instruction; data retrieval; and centralized library services.

d) government: fire and burglar detection; picture and finger-print record retrieval; remote "line-up" of suspects; interconnection between agencies; and traffic control.

Many similar applications come readily to mind, such as those related to urban development proposed by the National Academy of Engineering in its study of Telecommunications in the Urban Environment[19]:

a) health services: remote consultation at clinics with a centrally located physician; remote multisignal physiological diagnosis; pathology; observation.

b) municipal services: access to "city hall" from satellite centres; crime prevention and security systems for housing projects and public institutions; citizen-government interaction: a community information system.

This report[19] also suggests:

> "an exploratory program to examine how broadband communications technology could be applied to business, government, education, health care, and entertainment to stimulate the development of existing small communities, or new communities, in rural areas"

to offset the trend of more and more people living on a smaller percentage of the land. Use of the "Wired Scientific City" as a pilot model for communications in the cities of the future is a viable application.

The audio, visual, monitoring, and control components of the network provide the facilities for psychological experiments in human response measurement. The network allows the experimenter to reach subjects in many diverse organizations which he might not be able to do otherwise.

Experiments of a technical nature may also, of course, be conducted, such as wideband signal transmission and switched network studies.

The ultimate experimental applications of the system cannot be foreseen at this time and careful attention must be given to the specification of an experimental program during the implementation of the network. In the United States, the experimental use of "wired city" systems will receive intensive study and evaluation. For example,

> "The Office of Telecommunications Policy has accepted a proposal from Malarkey, Taylor and Associates in Washington, D.C., for tasks to be performed in connection with evaluating experiments for the 'wired city'. The proposal, when submitted later this year, will list and evaluate candidate experiments, evaluate locations and methods of operation, examine various funding arrangements, and prepare implementation schedules for experiments that are selected for further consideration."[20]

A major experimental activity in the "Wired Scientific City" would be the measurement of the effectiveness of the communications and of the network terminals. Because of the novel nature of these systems, it is very possible to overdesign experiments intended for the evaluation of the communications function. In fact, the definition of evaluation experiments is one of the main activities required during implementation of the "Wired Scientific City", as will be discussed. It is essential, as shown by preliminary experiments already done[21,22] that these experiments be carried out in a multidisciplinary environment. For example, in the Bell-Northern experiments[21], the experimenters reached the conclusion that, since multinational accents are garbled by speakerphones, only subjects speaking "unaccented Canadian" English should be used. A communications engineer would probably have suggested replacing the audio system. Both views must be present.

These studies indicate how difficult it is to examine the communica-

tions process in the "Wired Scientific City" through predesigned experiments as normally used by the psychologist. Evaluation must rely on both observations of the ongoing process and formal experiments. Some explicit experiments suggested for the network are:

1) The implementation of an information system to enable efficient and convenient use of the networks.
2) The dissemination of selected graduate courses from Carleton and Ottawa Universities.
3) The presentation of courses given by sessional lecturers employed in governmental laboratories, from their place of employment.
4) The presentations of seminars given at the Communications Research Centre, Bell-Northern, Carleton University, the University of Ottawa, Department of Communications, and the National Research Council.
5) The day-to-day administrative and technical communications between the Department of Communications and the Communications Research Centre.
6) The installation of terminals of the National Research Council Computer Aided Learning system at the nodes of the network.
7) The interconnection of the Low Energy Nuclear Physics group.
8) The operation of the diabetic metabolism cooperative experiment.
9) The extension of the Project 91 evaluation experiments and the Carleton teleconferencing experiments.
10) The development of management information systems activities by interconnection of the informal Ottawa group spanning Bell-Northern, Carleton University, and the Departments of Communications and Defence.

Some of the above activities, and several others, are described in considerable detail previously.

CHAPTER 2 - THE NETWORK

It is our intention in this chapter to describe the general characteristics of the system which our work to date suggests would be appropriate for a pilot "Wired Scientific City". The requirements and technical specifications of the system will be described, as will several possible alternatives for its realization.

More detailed preliminary considerations of network configurations and facilities are described in the Second Interim Report on the "Wired Scientific City Study".

As discussed previously, the system is to be used in three primary modes. The one-to-one mode, an evolution of the conventional telephone, is to enable discussions and working sessions between two individuals or groups, each at a different node in the system. The one-to-many mode (with some provision for many-to-one) is to provide for the conventional lecture sessions. Finally, the many-to-many situation arises during group discussions, and similar occasions. This last mode determines the primary characteristics of the hypothetical system as the other modes can be viewed as sub-sets of this mode. It follows directly from the many-to-many situation that the signals emanating at any particular node must be available at all other nodes. The system must have the capability to bring all users into a "common space".

A vital characteristic of an experimental system is that is be readily modified and varied. Below, we shall discuss a prototype system, but it does not follow that all nodes would have identical characteristics and facilities. Each node could, to a reasonable extent, adjust its particular facilities to its requirements and financial capabalities. However, at each node all communication signals originating within the system would be available, although private circuits could probably be appended to the system.

The communications "backbone" of the "Wired Scientific City" is taken to be television. Although colour would have obvious attractions, economics would appear to rule this out, particularly as there appears to be no distinctly identifiable colour requirements (as might be found, for example, in a communications sytem for some medical uses). The basis, then, will be black-and-white television with certain auxiliary services.

The video signals, of course, would be accompanied by the appropriate high quality audio signals but provision should be made for some additional services.

Obviously, communications using less extensive facilities such as

slow-scan television and telewriters are possible within the recommended broadband network. Indeed, comparative studies of the effectiveness of broadband and narrowband facilities could be an important area of research utilizing the network. Foremost among the other possibilities are a facsimile capability to exchange hard-copy documents and the capability for teletype-level computer connections. Some provision for video and audio recording warrants serious consideration and the capacity to interconnect with the telephone system would be valuable.

The sharing of resources, particularly computing power, is most desirable and indeed studies of this concept are being undertaken separately by other researchers.

Our studies to date have indicated clearly that each node should ideally originate two television signals. One channel, the most important one, would be devoted to a writing surface of page size or less through which prepared textural materials, handwritten notes, charts, diagrams, and so on, could be communicated. The other channel would be devoted to a general view of the person or persons communicating from a node.

The success of this, or any other pilot system, will depend in very large measure on the proper design of terminal facilities and on the development of appropriate systems hardware and software.

The aspects of this project which relate to user acceptability cannot be overemphasized. As the network itself must be reliable and utilitarian, both functionally and as a vehicle for experimentation, the terminal equipment must be suitably selected to meet the same goals.

The proposed pilot network - the "Wired Scientific City" - is an experiment and will be the medium for experiments. Consequently, it is not sufficient to simply provide a communications facility; a sufficient support system to monitor, record, and control the use of the network will be required.

2.1 Requirements

The general requirements that a pilot network must meet are:

1) provision of experimental, multinode broadband communications;
2) interconnection of a technically aware community of sufficient size and physical dispersion;
3) provision of the means for the collection of data relevant to the experiments being conducted and for the requisite

network control;

4) operational policies and procedures sufficient to encourage its effective use and to support on-going experimentation.

The pilot community and management schemes will be discussed in subsequent chapters, while this chapter will be devoted to consideration of the technical aspects of the network.

While a technically aware community has been proposed to minimize the inhibitions experienced by most people when confronted by a technically complex system or mechanism, it is still vital that the system operate well and that it be operative on installation. Even the most experienced research engineer becomes frustrated by system "crashes" and artificial constraints. Consequently, the pilot network must be well engineered and the basic concept would be severely jeopardized by a functionally inadequate system.

While a system is being discussed which is "open" in terms of its use in most of its functions, it must be appreciated nevertheless that some use of the system could well be such as to require privacy. A basic network is proposed which does not have privacy as an essential element, but which does allow readily the addition of privacy - either by separate channels or by the control function.

Conversion of these general considerations into more detailed specifications yields:

1) the network must support duplex video/audio communications in three modes: one-to-one, one-to-many, and many-to-many;
2) basic terminal equipment should be provided as a part of the network;
3) it must allow for experimental wideband signal transmission without interference with commercial or existing communications;
4) its capacity must be extendible without further construction or regulatory negotiations;
5) it must be capable of providing for private channels;
6) it must be implementable within a reasonable period of time;
7) it must provide for immediate use in an experimental functional role;
8) the network must be reliable and maintainable;
9) the network must include provision for the monitoring of its usage and be capable of automatic control;
10) it must be free from constraints on the mode of usage;

11) it must be capable of supporting both scheduled and unscheduled communications;
12) it must incorporate a scheduling system to facilitate usage.

2.2 Technical Specifications

2.2.1 Bandwidth

With six nodes, five single or dual incoming channels and one outgoing channel are required at each node. In a simple loop configuration as illustrated in Figure 4 , five channels are required between each node. While a dual, or two-channel, configuration is desirable, as explained previously, a more economical approach would involve a single channel. In that case, it would be desirable to generate the two signals at each node, but to transmit only the most essential one at any point in time. Consequently, the minimum total net bandwidth required, allowing for initial requirements, system flexibility, monitoring and control, and expansion amounts to about 60 MHz for single channels or 100 MHz for dual channels.

Even if this were expanded to 150 MHz, it might well place a limit on the transmission of wideband experimental signals that would be too restrictive.

2.2.2 Transmission Equipment

To meet the requirements of video communications, it is proposed that standard monochromatic television and reception equipment be used, and that provision be made for:

a) the transmission of at least one 6MHz video signal from each node and;
b) the reception of the signals from every node at each node.

The ready availability of standard television equipment at modest cost makes such a decision imperative.

It is further proposed that these signals be demodulated to baseband upon reception. Additionally, it is desirable that the full available bandwidth be accessible, with appropriate controls, at each node for both transmission and reception.

2.2.3 Switching

Control of the distribution of signals in the pilot network can be

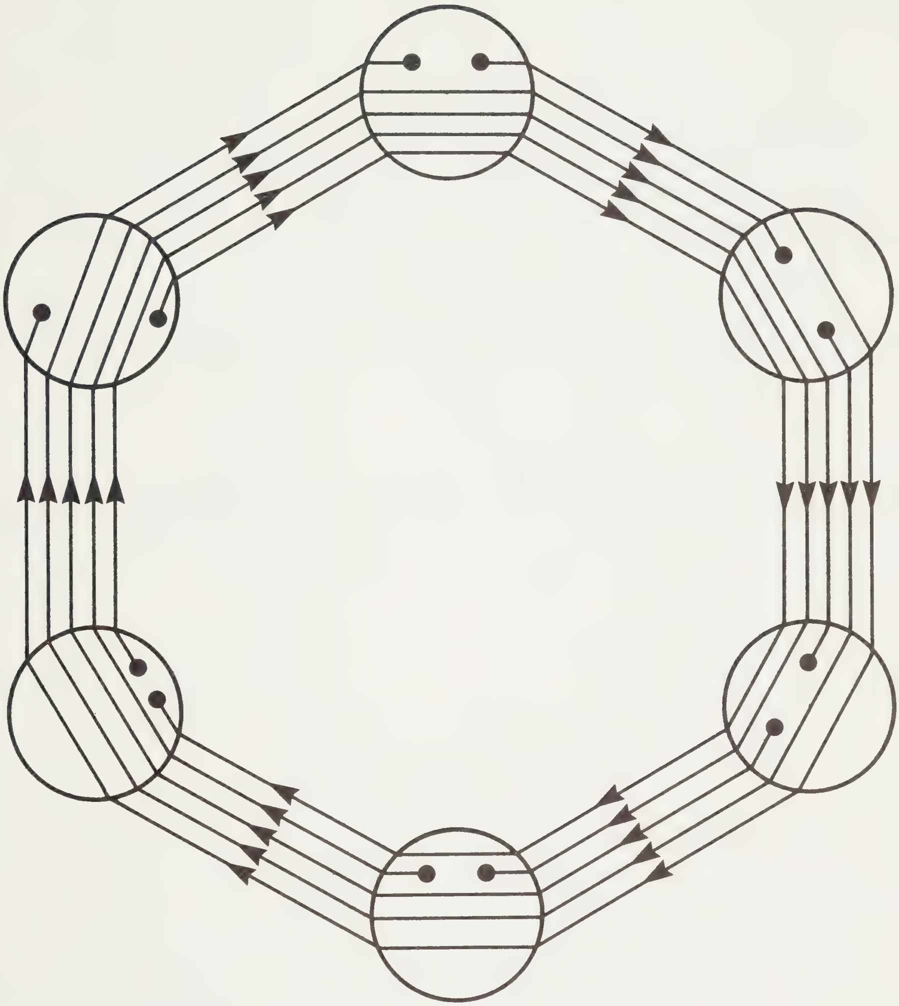


Figure 4 Six-Node Loop Network.

implemented by the use of simple switches at the nodes. (Even though it is not recommended, such an arrangement allows for provision of the basic communications with no switching whatsoever). An example of such a node switch is shown in Figure 5. This switch was intended for use with the loop network illustrated in Figure 4.

The purpose of the switching is to allow for the introduction of control and monitoring functions to meet those specifications previously described, relating to privacy, scheduling, experimentation, and monitoring.

2.2.4 Monitoring and Control

There are two types of monitoring required in networks. The first relates to the collection of data pertaining to experiments: the major experiment, i.e. the network itself, and experimental applications of the network. Some examples are:

a) time of use;
b) duration of use;
c) purpose of use;
d) configuration during use;
e) number of participants;
f) mode of use;
g) communications facilities utilized.

The second relates to the monitoring of the operational status of the network for control and maintenance purposes. Network configuration, signal qualities, and general operational status of equipment could be continuously monitored and recorded. Such feedback could well be an essential ingredient of effective system control during experimentation.

The most elementary level of control would be provided by the switching discussed in the last section. More elaborate forms of control, associated with experimentation are readily visualized. For example, measurement of the effect of signal quality and associated image resolution on the effectiveness of communications would involve controlled variation of signal amplitudes, bandwidths, and so on.

As indicated before, the control function is not essential to communications within the "Scientific Wired City", however, a fully equipped experimental facility would contain a medium-sized digital computer and appropriate data communications sub-system. These would be incorporated

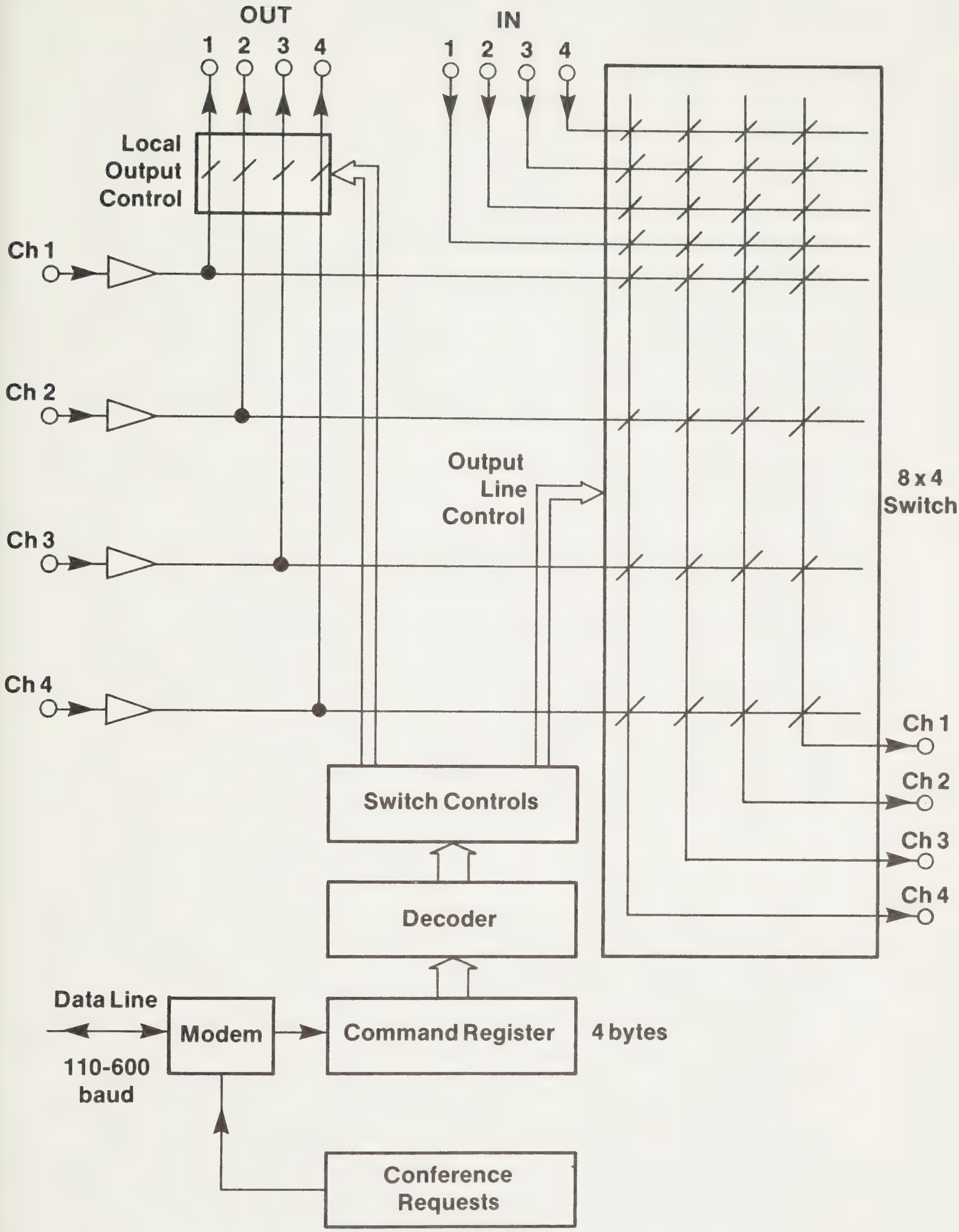


Figure 5 **Multiple Input Node Switch, with Computer Control.**

This example shows a switch in which both the local outputs and the line outputs are controlled by data received from a central computer.

into the pilot network to monitor the status of channel usage, switching configuration, signal qualities and general operational status of the network. It is proposed that control of the network as regards transmission and reception access by various modes, would be exercised through this digital system. The computer would be used to generate reports on system status, usage, scheduling, and other data as required. It is proposed that a selective address, command/status word, information structure be used.

It is noted that the switching in the network is distributed, i.e. takes place at the nodes.

2.2.5 Terminal Configurations for Video Communications

Basically, terminal facilities should provide for the origination and reception of audio and video signals in a setting appropriate to the type of communications being carried out. Since the "Wired Scientific City" is proposed as a multipurpose network, specific terminal configurations can vary from those designed to serve the student viewer, through the needs of the two-group managerial conference, to those of the multistation discussion. The variety of configurations that is possible, while determined primarily by functional requirements, is limited only by the imagination of the designer and the financial constraints of the owner. As a basic rule, terminal "stations" should be properly designed: the user acceptance of any equipment will be enhanced by correct psychometric layout of the equipment, suitable software support, and ease of utilization. Industrial designers familiar with man-machine interactions should be consulted during the design of terminal stations.[17]

The differences between various terminals are caused by:

1) the number of images generated and received;
2) the degree of control each participant can exercise over which images he can transmit or receive; and
3) the number of people involved at each site, including switchers and operators.

Two suggested terminal configurations are presented. While two video signals are preferable, in the interests of economy in the pilot network both terminals are based on the assumption that one signal is actually transmitted from the local node. The terminals are:

a) an "individual" position, suitable for lecturers, collaborators, students and seminar attendees (without cameras),and for use as

a building block for conference terminals; and,

b) a two-group conference terminals.

Actual designs for terminals to be used in two-way television teaching are also given. It must be emphasized that these are representative only, and are not intended to be the last or only word in terminal design.

The first suggestion, for the individual terminal, is shown schematically in Figure 6. This terminal is based on a large (14") monitor surrounded by 5" preview monitors. Any image shown on the preview monitors may be selected for viewing on the large monitor. Two cameras are affixed to the terminal, one to view documents and the writing space, and the other the participant, equipment, blackboards, or other general views. The user has control over which camera image is transmitted. The audio portion of the terminal consists of speakers and a noise-cancelling microphone, with appropriate amplifiers. This terminal may also be used by two or three persons, but with a reduced capability for interactive participation.

The estimated cost of this unit is approximately $10,000, including two cameras with 800-line horizontal resolution fitted with 4:1 zoom lenses, a synch generator with genlock capability, audio, solid state monitors, a passive video switcher, and a simple video programmer. The cost can be reduced to about $7,200 with lower quality cameras, fixed lenses, and a simpler synch generator.

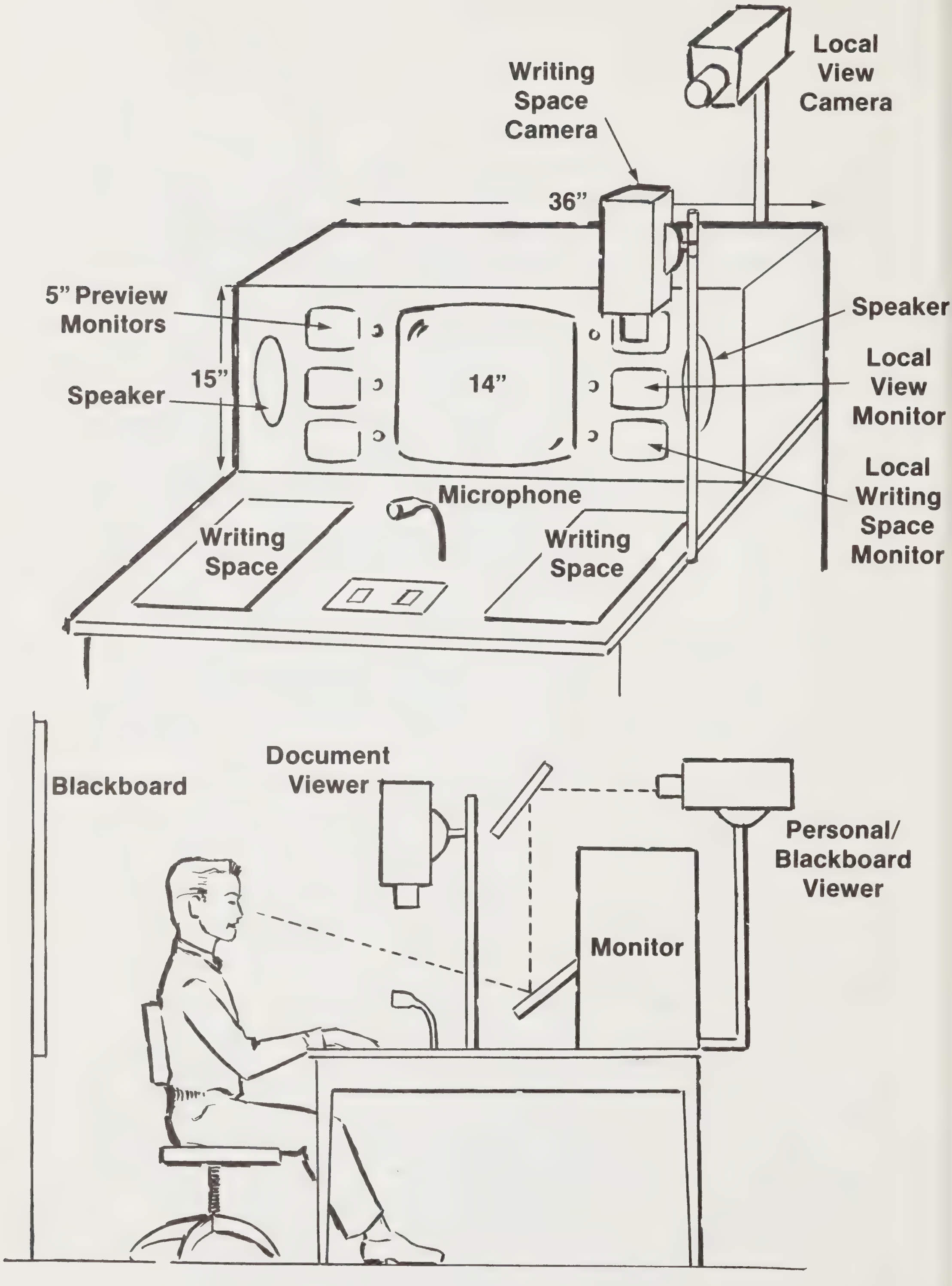
The second suggestion, for a group conference terminal, is shown in Figure 7. There, cameras A and B are used under operator control for views of the participants. Pre-set remote pan-tilt units are employed to aid the viewing of speakers. A document/writing space viewer is provided for each position. The transmitted image is controlled by the operator. Local writing space images, the transmitted image, and received images can be viewed by each pair of participants, who likewise share microphones and speakers.

Note that the individual position terminals, with a complement of three 11" monitors, may be used to form the conference terminal.

The cost of the eight person conference room shown is approximately $24,000, it may be reduced to $20,000 with only one document/writing space viewer.

The equipment for a two-way teaching facility, with four cameras, costing a total of $22,500 is shown in Figure 8. Included is a remote

Figure 6 The Basic Individual Terminal.



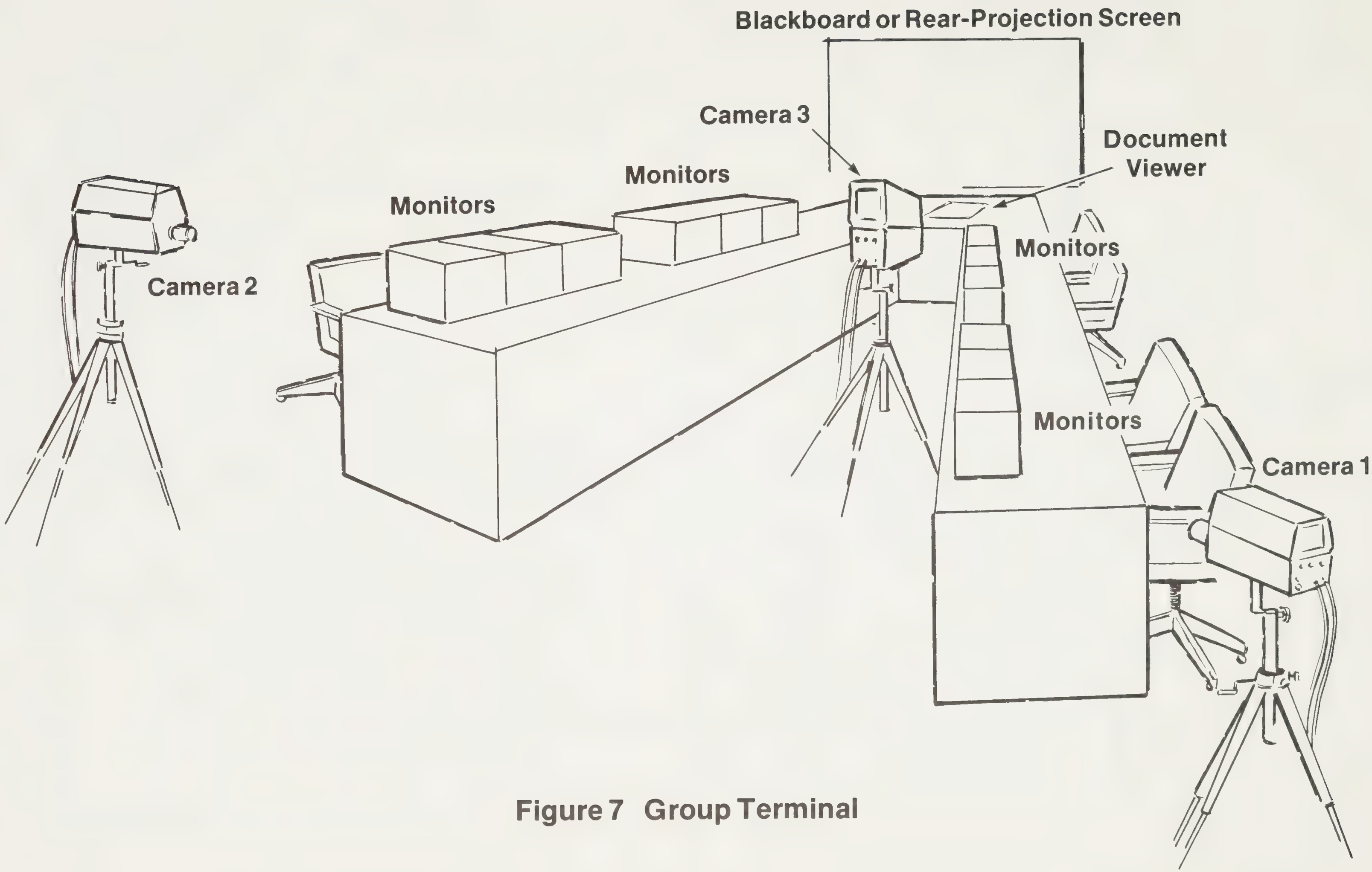


Figure 7 Group Terminal

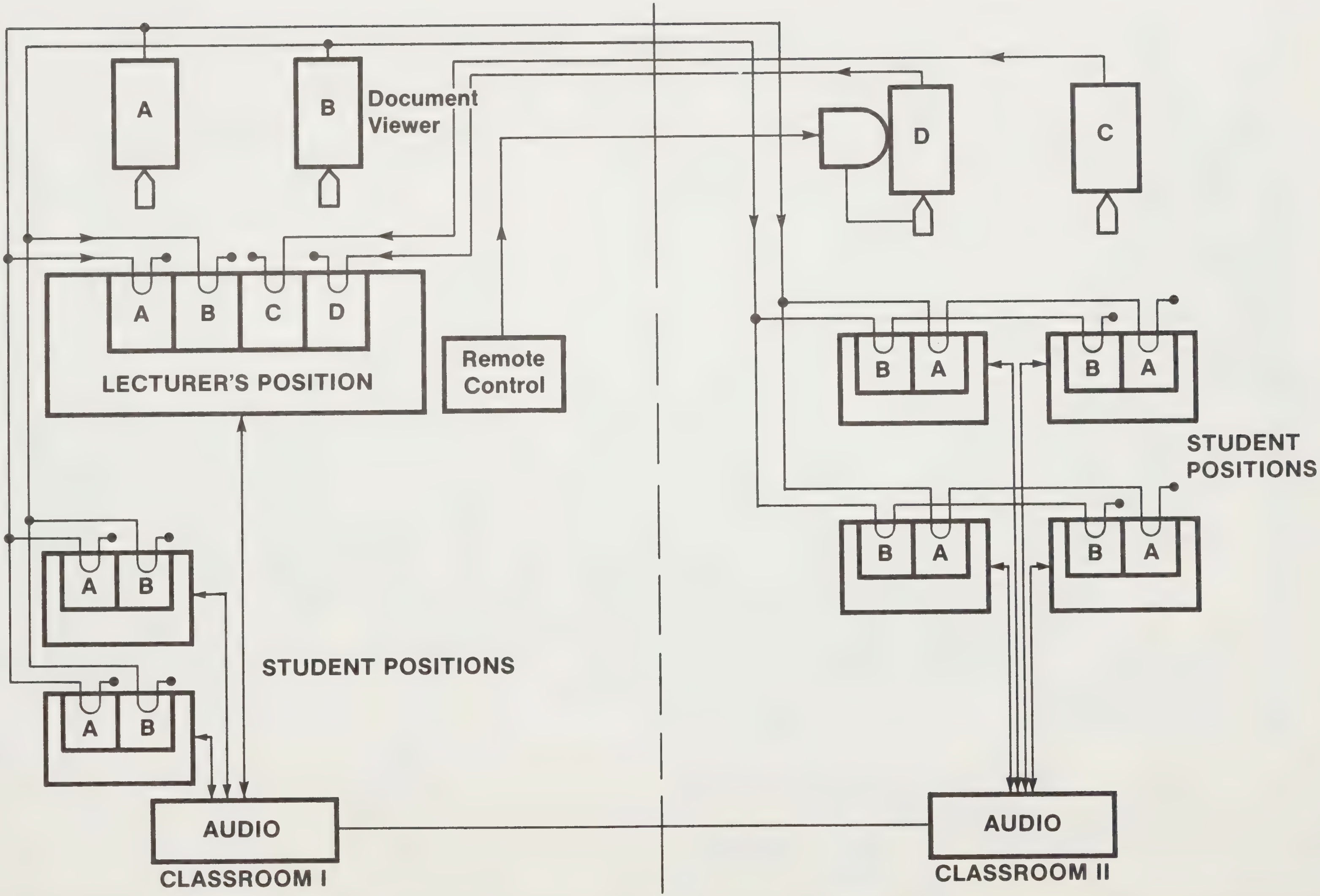


Figure 8 Two-Way Teaching Facility.

controlled camera in classroom 2, controlled by the lecturer in classroom 1. Students use "positions" consisting of a pair of high-definition monitors and microphone and speaker facilities, while the lecturer has a document/writing space camera and can monitor all images in the system. The audio facilities are connected as a closed loop with noise-cancelling microphones and push-to-talk switches to reduce feedback problems.

Terminals were specifically discussed in Chapter 2 and Appendix 6 of the Second Interm Report.

2.3 Alternative Implementations

There are a number of ways of implementing the network. They fall into two categories: leased and owned. Either way may involve cable and/or microwave facilities, and may involve control over the total available bandwidth of the system or the sharing of it with other users. Several preliminary implementations were considered in Chapter 1 of the Second Interim Report. The details of possible implementations will not be elaborated upon in this section, except in a summary fashion.

2.3.1 Existing Facilities

This implementation is defined as the leasing of channels from the broadband plant of the local common carrier. This provides perhaps the fastest implementation and introduces neither regulatory nor interference problems. Further, responsibility for maintenance of the transmission network rests with the common carrier. However, it does require an exact specification of the bandwidth requirement, constrains signal types to those permitted in the existing plant, and poses real problems vis-a-vis bandwidth expansion. Certainly, the existing plant was not designed for experimental broadband transmissions.

Two basic alternatives exist here. Either television channels or direct access to bandwidth may be leased. The second, while placing greater equipment responsibilities on the operators of the network, does provide for greater flexibility. Yet further variations are introduced by the detailed allocation of responsibility for, and ownership of, the various components of the transmission facilities, including the available bandwidth.

The costing details of some particular implementations using the facilities of Bell Canada are given in Appendix A.

2.3.2 Independent Microwave Facilities

The use of an independent microwave radio system has the advantage that there are no wires to be placed in underground conduits, although the provision of towers to provide reliable line-of-sight transmission paths may be awkward. It has the advantage of portability, i.e. nodes may be relocated in a relatively simple manner. Other advantages include area broadcasting which might be particularly appropriate for the topology of the proposed system and the educational function. It is possible that the new "pole-line radio" systems or even optical transmission would have an application here, particularly for temporary or portable extensions of the basic network.

Microwave radio does suffer from the following disadvantages:

a) suitable frequency allocations may be difficult to obtain;

b) there seems to be a lack of availability of very wide bandwidth (100 to 200 MHz) transmitters and receivers;

c) absolute privacy is difficult to ensure, as the signals are available to anyone with the appropriate equipment.

2.3.3 Independent Coaxial Cable Facilities

Implementation using completely dedicated coaxial cables meets the requirements for control of the full bandwidth of the system and non-interference with other on-going communications. Installation in an urban environment can be exceedingly difficult. Construction costs, and the cost of the maintenance of a large number of line amplifiers (2 or 3 per mile) can be considerable. A clear advantage is that relatively large bandwidths (up to 200 MHz) can be made available. As discussed in Section 1.2.4 of the second interim report, an independent coaxial cable system could be installed for approximately $180,000, with operating costs of about $30,000 per annum.

From a technical viewpoint coaxial cable is the transmission medium to be preferred. The existence of CATV technology, at moderate cost, is encouraging.

CHAPTER 3 - IMPLEMENTATION AND MANAGEMEN

3.1 Introduction

It has been proposed in previous chapters that the "Wired Scientific City" will be a multi-purpose facility for both functional communications and for experiments in several disciplines concerned with communication and communications. The network is therefore an experimental paradigm in its own right and at the same time a facility for conducting experiments. Certain areas for possible experimentation and development are already apparent:

a) Certain technological aspects of broadband communications systems, including both network design and signal generation and reception.

b) The design of a subsystem for monitoring, control and measurement.

c) Economic studies on broadband system operation including, for example, plant installation, evolution and maintenance, tariffs, operations, and so on.

d) Research, from a psychological and sociological basis, on the use of broadband communications and its effects.

e) Formal and informal educational uses.

f) Remote use of experimental and computational equipment and information resources.

The hardware aspects of the network to enable these and similar activities, as well as to provide the communication function has been described in Chapter 2.

It is not sufficient to build such a system without it being properly managed and operated. This chapter will consider the management and funding aspects of the implementation and operation of the system. It is not proposed here to develop a thesis on project management; however, it is our intent to emphasize that unless due regard is paid to the organizational aspect of the venture that many significant returns will not be realized due to errors of commission and omission. Thus this chapter highlights several items which could be a guide to both the acquisition and operational phases of the project.

In describing a general procedure within which the "Wired Scientific City" is to be implemented, there are a number of details that must be settled. These can be decided only by negotiation with the participants, and cannot be predetermined. Among the various items which will require detailed negotiation and decision are:

a) the selection of the participants and the system nodes;
b) the responsibility for design, purchase, operation and maintenance of the specific components of the network;
c) the nature, size, responsibilities, and location of the operational and management organization of the system;
d) the scheduling of the implementation;
e) procedures for the "in-use" evolution of the system as dictated by operational experience and experimental needs;
f) duration and phasing of the "Wired Scientific City" experiment;
g) detailed modes and ranges of use.
h) priorities of use;
i) degree of automation within the system;
j) development of a system for monitoring and control;
k) processing and reporting of collected data;
l) degree of user training and related documentation;
m) degree of support provided to users for implementation and execution of experiments.

These and many other questions influence the form of the eventual organization and its tasks and dictate the investment required to generate a viable experiment.

Notwithstanding the lack of resolution of these innumerable details, it is possible to describe features of the implementation and management for the "Wired Scientific City" project. Clearly, there are three major phases to the project following "approval in principle" viz.,

a) the decision phase, during which the configuration of the network is confirmed and many of the points raised above negotiated.
b) the implementation phase, during which physical implementation and operating procedures are effected, operational management procedures are designed and implemented, experiments are designed, the system is commissioned, and users trained.
c) and finally, the operational phase, during which the system provides the desired functional and experimental base.

These major steps are illustrated in their proper sequencing in Figure 9

3.2 Implementation

The first essential step in the process of physical implementation is the detailed technical decision among the various alternative imple-

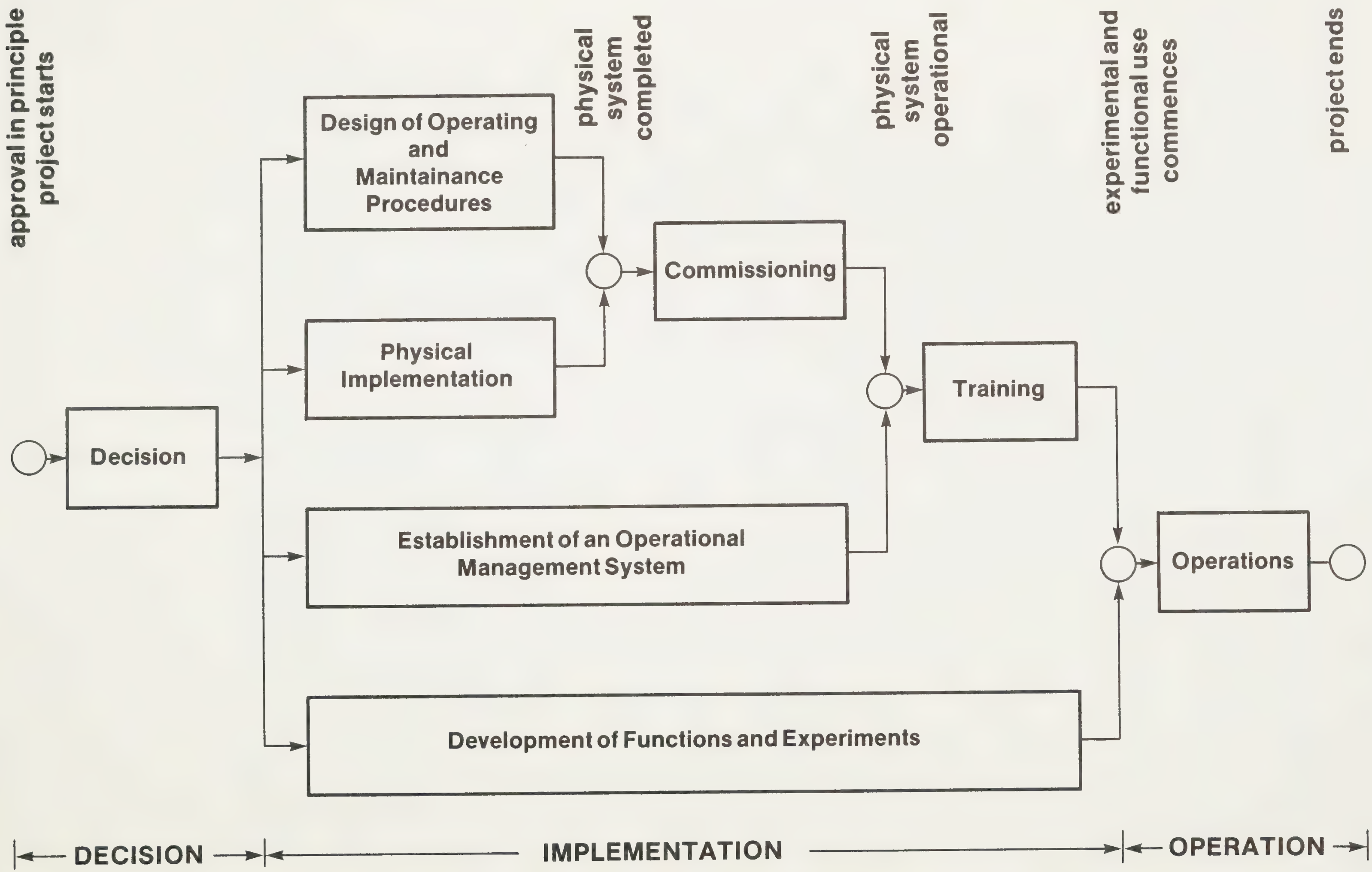


Figure 9 Project Stages.

mentations as discussed in Section 2.3. Along with this goes the design of the details of the network configuration. The extent to which these facilities are rented from a communications company or constructed as a private network will determine the extent of the next step. If television channels are rented from a common carrier virtually no work on the network itself need be done. At the other extreme a great deal of detailed engineering work, equipment procurement, and construction would be required. This has obvious staffing implications. These same considerations would apply to the operation and maintenance of the network.

In parallel with the physical implementation of the network itself, terminal facilities and a monitoring and control subsystem must be designed, procured, and installed. There is little possibility of outright purchase of total systems of these kinds. They would of necessity be obtained through contract or development within the resources of the project itself.

Once the system is installed and adequate operating and maintenance procedures arranged, a commissioning phase is entered. During this phase the system will be proved.

At the same time as these physical arrangements are being made, it is necessary to establish a suitable operational management system for the "Wired Scientific City". It is necessary to establish methods and personnel to handle the following managerial functions:

a) instrumentation of operating and maintenance procedures;
b) acquisition and training of technical personnel, or equivalent contractural arrangements;
c) establishment of a maintenance and operations information system for the users;
d) establishment of a scheduling system and a related priority structure;
e) financial and personnel management;
f) interaction with contractors and "clients";
g) publicity and documentation, handling visitors, etc.;
h) response to the requirements of the functional users of the system and the experimentors.

If these and other similar functions are not arranged for concurrent with, and interacting with, the physical development of the network, the "Wired Scientific City" would not be functional.

As the diagram (Figure 9) illustrates, once the management system

is developed and the network is commissioned, a training phase can be commenced preparatory to placing the system in operation.

During implementation, it will be necessary to develop experimental plans in some detail. As well, arrangements for functional use (seminar series, lecture courses, conferences and consultations, etc.) must be confirmed. The development of appropriate experiments is a problem of considerable complexity requiring contributions from the social sciences as well as the applied sciences.*

While the several primary tasks of implementation are taken to be separate for purposes of description, this is certainly not the case in reality. All the functions shown in Figure 9 must necessary interact and a full diagram giving all feedback and feed-forward paths would be confusing.

3.3 Organization and Management

The organization required for the project may be considered in two major phases: the acquisition and implementation phase, and the operational phase. A separation of responsibilities is proposed. The implementation and operation of the physical facilities shall be separate from the selection, design, and execution of experiments. More precisely, the responsibility for, and management of, these two functions shall be separate within the overall organizational structure of the "Wired Scientific City". To have them combined would produce a basic conflict of interests between the desire to maintain and operate a high quality communications system and the desire to experiment. It is important to remember that the system has an important group of functional uses and users and, the type of conflicts which arise in many computing centers must be avoided. In the authors' own experience, a small hybrid computing system has failed to become a totally functional facility because of a conflict between those who wish to use the system and those who are engaged in its continual physical evolution.

It is expected that the basic separation outlined above will make the organizational structure responsive to the functional demands made of the system. The other major "inputs" are the policy requirements created by the basic objectives of the "Wired Scientific City" experiment itself and, most importantly, the objectives of the various sponsoring

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* The difficulties of pre-design of suitable experiments is vividly illustrated in Reference 21.

agencies. This implies that a major management function required of the organization will be resource allocation - the establishment of the priority of each and every desired use of the network.

With these responsibilities clearly defined, it remains that the system management be accountable to the sponsoring agencies so that, insofar as it is physically and humanly possible, the "outputs" from the project shall meet the objectives of the sponsors.

This leads, almost uniquely, to the organizational structure shown in Figure 10. It consists of a Board of Directors, responsible for policy; a Project Office, responsible for operations; and a Program Committee, responsible for the experimental program.

3.3.1 Board of Directors

The Board of Directors shall comprise representatives from each major sponsor, each participating organization (i.e., node on the network), the Director of the Project Office, and the Chairman of the Program Committee. The detailed constitution of the membership of the Board would require the agreement of major sponsors and participating organizations. From amongst its members, it shall select a Chairman and a Secretary. Once the project has obtained "approval in principle", an interim Board of Directors would be formed which would be the principal medium for the series of decisions required in order to move from "approval in principle" to "confirmation of the configuration" (Figure 9). When this stage is reached, the Board of Directors shall be responsible for:

a) relationships with the sponsoring agencies and the participating organizations.
b) the definition of policy guidelines for the Program Committee and the Project Office.
c) the appointment and re-appointment of the Director and the Project Office and the Chairman of the Program Committee.*
d) review of the activities of both the Project Office and the Program Committee and of all of the functions and experiments carried out on the network.
e) the attraction of funds for the use, study, and evolution of the system.

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* The Chairman of the Program Committee and the Director of the Program Office would not participate in this function.

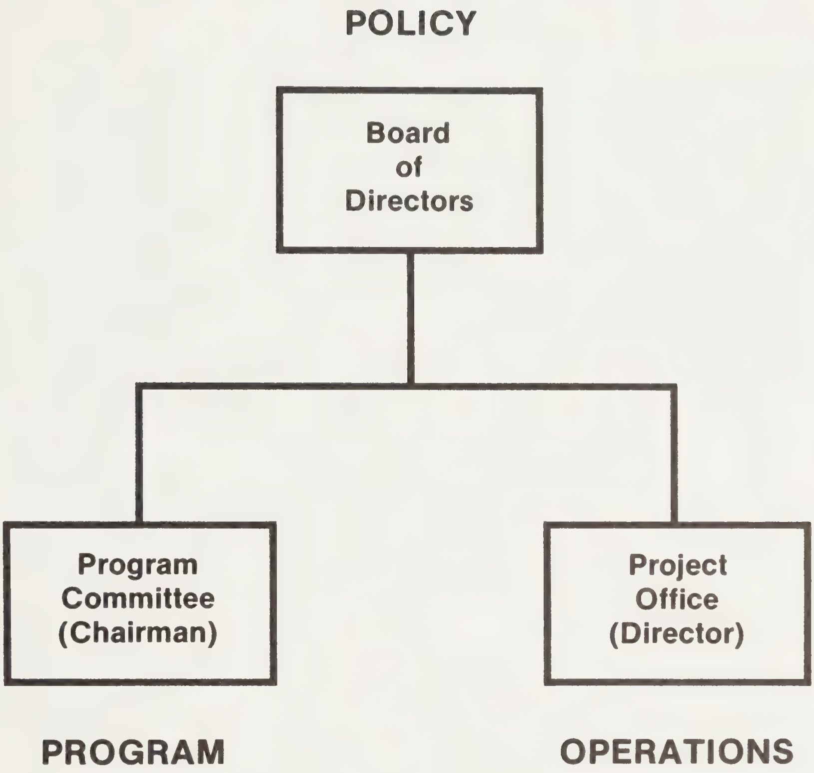

Figure 10 Management Structure.

3.3.2 Program Committee

The Program Committee shall include a voting member from each of the sponsoring agencies and participating organizations, and a non-voting member concerned with each particular function and experiment. It shall have a Chairman selected by the Board of Directors and who shall be employed full time and be responsible for the experimental activities of the project. He must possess sufficient managerial capability to lead and to implement the decisions of the Program Committee. The Chairman should have the capability to conduct sociological and psychological studies and have a broad understanding of telecommunication systems. The Director of the Project Office shall be the non-voting Executive Secretary of the Committee.

The responsibilities of the Program Committee shall include:

a) the formulation of detailed policy and procedures for the selection and evaluation of network functions and experiments of all kinds;
b) the selection of those particular uses of the network which shall be activated;
c) the establishment of priorities when required;
d) the requisition and evaluation of progress and terminal reports from all system users;
e) efforts to attract suitable projects involving the use and study of the "Wired Scientific City";
f) the organization and conduct of studies of the use and effectiveness of the network, particularly in those areas where there is inadequate activity or a requirement for coordination of several activities. These studies, and personnel employed thereon, shall be the direct responsibility of the Chairman.

All users shall be responsible for the organization, management, et cetera, of those aspects of their experiments which lie outside of the communications facilities of the network.

3.3.3 Project Office

The Project Office shall be the responsibility of a Director selected by the Board of Directors. Since the major responsibility for the successful implementation of the system and its satisfactory operation depends on the Director, he must be a person with appropriate experience and capability. His office shall have the responsibility for:

a) the physical implementation, the design of operating and maintenance procedures, establishment of an operational management system, the commissioning of the system, and the training of operators and users.
b) the technical operations, including scheduling and maintenance.
c) the secretariat facilities for the Program Committee and the Board of Directors.
d) the disbursement of funds in both the implementation and operational phases.
e) provision of administrative support for research personnel working under direction of the Chairman of the Program Committee.
f) technological support of use and effectiveness studies (see f under 3.3.2) and conduct of technological development in those areas in which there is inadequate activity.

As a consequence, the Project Officer requires both technical and clerical personnel.

3.4 Costs and Funding

Once "approval-in-principle" is made, as mentioned above, an interim organizational structure is immediately required. Not only will the Board of Directors need formation, but also the key personnel of the project must be acquired. Their inputs in organizing the details of the implementation stage are essential. By the time the configuration is confirmed, the full staffing requirements for the project should be available to proceed with implementation. Of course, once implementation is completed this staff will be fully occupied with the operation of the network and associated studies.

A visualization of the cash flow throughout the project is given in Figure 11. Clearly, the details of the cash flow are totally dependent on the detailed decisions subsequent to "approval in principle". Even the order of magnitude estimates to be given in this section necessitate certain critical assumptions which are taken, in this report, on the basis that they appear to be the most likely. After the initial staff build-up, described above, the early implementation stage will require expenditures for consultants and contractors to support the detailed design process. As this begins to terminate, capital expenditures related to the procurement of terminals and the monitoring and control system

will begin. Shortly thereafter, rental of some of the communications network will be required for test purposes. As time progresses, capital expenditures will decrease and rental costs will grow to their final value. At the end of the project, a reduced staff will prepare final reports.

Certain assumptions regarding the nature of the resulting system are self-evident in the above.

3.4.1 Staff Costs

The Director of the Project Office and the Chairman of the Program Committee are full-time professional level personnel. As above, it is assumed that the communications network is leased from a common carrier who is responsible for its maintenance. Also, it is taken that the participating institutions (nodes) have sufficient in-house technical facilities to maintain their terminal equipment under advice from the Project Office.. It is not proposed to fund, through the "Wired Scientific City" project itself, the optimum level of study and experimentation. Rather, the proposal is to provide the essential level necessary to prevent failure.

The annual staff costs for the Project Office are:

Director	$16,000
Project Engineer	12,000
Technicians (2)	16,000
Secretary (2)	13,000
	57,000
Overhead (space, supplies transportation, etc.)	28,000
	$85,000

and for the Program Committee:

Chairman	$20,000
Research Assistants (2)	22,000
	$42,000

This yields an annual staff cost for the duration of the project of $127,000.

3.4.2 Design Costs

In addition to the full-time staff who will bear the responsibility for detailed design and implementation there will be a need for additional assistance by consultants and contractors. As we are assuming rental of the communications network, we shall not include design costs associated

with this element. Design of the overall project, of the monitoring and control subsystem, and of the network terminals will comprise the major effort. It is estimated that $50,000 in consulting contracts shall be required. Considering the amount of work required, it is taken that one of the three primary design tasks will be contracted.

3.4.3 Capital Costs

Capital expenditures will be required for the network terminals and for the monitoring and control subsystem.

For the terminals, experience gained in related work at Carleton University suggests that a minimum basic terminal station which would include two cameras, six monitors, synchronization equipment, audio facilities, and appropriate "furniture", would cost $15,000. When one considers that three different functions are possible (one-to-one, one-to-many, and many-to-many) in the use of the network, a more fully developed terminal could cost in the order of $45,000. This would involve some unavoidable electronic and functional duplication which would be convenient in multinode use of the network. These estimates do not include procurement of auxiliary narrow-band terminal equipments, such as alphanumeric displays or facsimile.

Based on the assumption that the monitoring and control subsystem includes a centrally located digital computer, its capital cost is estimated at $100,000. This cost is arrived at as follows:

Central Computer (with communications and storage)	$40,000
Five Terminals	60,000
	$100,000

and does not include data modems and communication channel costs. In the absence of a detailed design for the subsystem, this estimate is necessarily arbitrary. It does include, however, the possibility for consideration of a network of minicomputers and their operating software which would yield a system of great flexibility.

Summarizing the above gives, for a five-node network, a total capital cost which varies from $175,000 to $325,000.

3.4.4 Rental Costs

As a result of discussions with Bell Canada, summarized in Appendix A, rental costs for a five-node, two-channel, two-way, video system are

estimated to be approximately $10,000 per month. This cost could be reduced by use of single channels as has been discussed elsewhere.

Rental costs will also be incurred for dedicated telephone lines and modems associated with the monitoring and control subsystem. These would amount to $1500 a month for a five-node network.

3.4.5 Summary

Based on the above, annual operating costs are:

Staff	$127,000
Communication Rentals	$138,000

and non-recurring costs are:

Consultants and Contracts	$ 50,000
Equipment	$175,000 - $325,000
Miscellaneous (office equipment, test equipment, installation charges)	$ 10,000
Total	$235,000 - $385,000

With reference to Figure 11, and making some assumptions regarding the time scale of the project and allowing $300,000 for non-recurring costs, the total cost of the "Wired Scientific City" project is estimated to be:

		Total
1st six months		
Staff	$63,500	$63,500
2nd six months		
Staff	63,500	
Consulting	40,000	103,500
3rd six months		
Staff	63,500	
Consulting	10,000	
Capital	100,000	
Rental	4,000	217,500
4th six months		
Staff	63,500	
Capital	200,000	
Rental	34,500	298,000
3rd year		
Staff	127,000	
Rental	138,000	265,000
4th year		265,000
5th year		265,000
6th year		
Staff		63,500
		$1,541,000

Thus, the total cost of the project is estimated to be approximately one and one-half million dollars, or an average of $250,000 for each of its

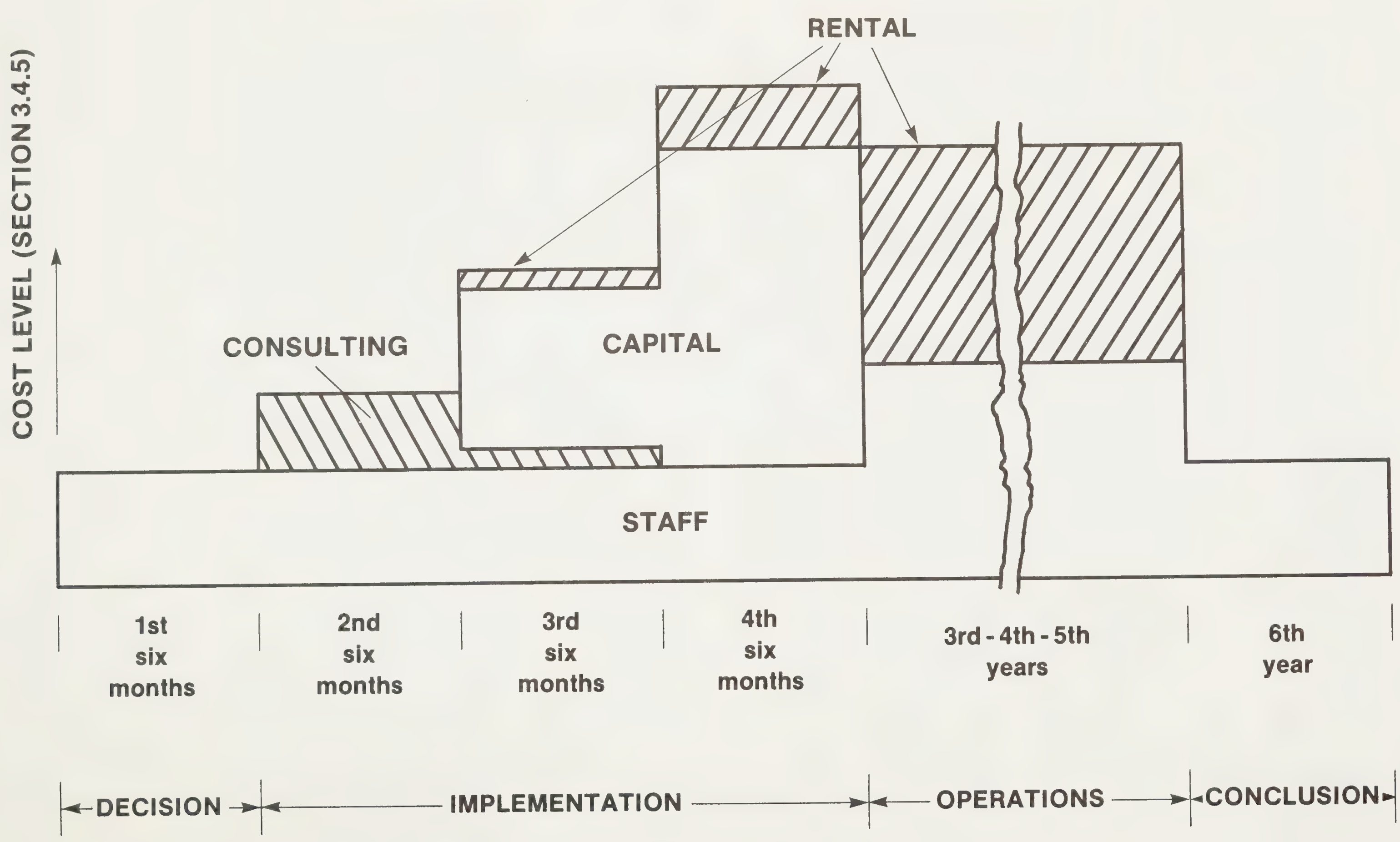

Figure 11 Cash Flow

six years of life.

3.4.6 Funding

To create the proposed "Wired Scientific City" prototype it is evident that some single agency must accept primary responsibility for funding. However, it is to be emphasized that the total effects of the advent of the wired city transcends any single interest. It is proposed that many departments of government at the federal, provincial and municipal levels are potential beneficiaries as are many components of private industry.

Possible initial contributors are:

a) the Department of Communications;
b) the National Research Council and the Canada Council;
c) Bell Canada and the Trans Canada Telephone System;
d) CN/CP Telecommunications

Other potential contributors are numerous and include:

a) the Science Council of Canada;
b) the Department of Industry, Trade and Commerce;
c) the Central Mortgage and Housing Corporation;
d) the Ontario Department of Education and the Department of Colleges and Universities of Ontario;
e) Hydro-Quebec and Ontario Hydro.

Because of the diverse sources of funding it would be necessary to establish the project as a distinct legal entity or to locate it within a "neutral", non-profit, non-governmental, institution with the facilities to provide the necessary administrative and legal support. The costs as developed do not provide for separate incorporation.

A university site would satisfy the conditions above, and would also encourage both personal and financial contributions from the many disciplines required to exploit fully the potential of this pilot network. Also, commercial exploitation of developments arising from the project would not be impeded.

CHAPTER 4 - RECOMMENDATIONS

Widespread recognition of the wired city concept and the emergence of prototype systems in various countries strongly suggests the imperative for a Canadian experiment. As has been recognized in the last decade or two, the Canadian communications environment is unique and the importance of communications to Canada suggests obvious dangers if this "revolution" in communications is simply imported. Chapter 1 describes at length a particular sub-society in Ottawa which is particularly suited to a major experiment in communications. It is recommended that a "Wired Scientific City" be established in Ottawa to connect five nodes:

- The Department of Communications, in downtown Ottawa
- The Communications Research Centre, located at Shirley's Bay
- Bell-Northern Research, located at Crystal Bay
- Carleton University, on Colonel By Drive
- The University of Ottawa, in Sandy Hill

A possible sixth node would be the National Research Council, on the Montreal Road. A map showing these sites is the frontispiece of this report.

Particular groups at these locations have been suggested as primary parties in the pilot project because their research and development activities are relevant to the objectives of the project; and they have the technical expertise to handle the communications and terminal equipment. It must be emphasized that it is not suggested that these groups would necessarily be either the first or the major users of the pilot network, but it is expected that these groups are likely to be concerned with experimental applications of the network. The particular groups are:

1) at the Department of Communications, the offices of the Assistant Deputy Ministers for Policy and Plans, and for Research;
2) at the Communications Research Centre;the Informatique Directorate;
3) at Bell-Northern, the Distribution Systems Engineering Section;
4) at Carleton University, the Systems Engineering Division;
5) at the University of Ottawa, the Electrical Engineering Department;
6) at the National Research Council, the Information Sciences Section.

The technical features of the proposed network have been described in Chapter 2 and in the Interim Report. Implementation of the required broadband communications facilities should be by means of coaxial cable

between the nodes. It is expected that facilities leased from Bell Canada would be the most practicable approach. These facilities would provide conventional baseband video and audio service, and the capability for experimentation with wideband signals.

As developed in Chapter 3, the success of the project requires an adequate and carefully organized management structure. An independent, non-profit organization is proposed to manage the project, and would have the following structure:

- A Board of Directors, responsible for policy.
- A Project Office responsible for operations.
- A Program Committee, responsible for the experimental program.

Included would be a full-time staff of nine. This structure reflects a basic premise that the project will function best with a fundamental separation into two groups - one responsible for operating and maintaining the physical facility and administrating the project itself, the other responsible for the experimental program.

The project should be conducted in three phases: decision, implementation and operation. Several primary tasks must be completed:

- Physical implementation of the communication network, terminals, and monitoring and control sub-systems.
- Design of operating and maintenance procedures.
- Development of an operational management system.
- Arrangement of appropriate functional uses of the system and design of an experimental program.
- Commission of the network and training of operating staff and users.
- Operation of the "Wired Scientific City" and conduct of the experimental program.

Financial support from a variety of agencies is visualized. Primary funding is recommended to be by the federal Department of Communications It is estimated that $1.5 million will be required, an average of $250,000 for each of the six years of the project.

Other specific, but less critical, proposals are found throughout the previous chapters.

APPENDIX A

Channel Rental Costs

As a result of discussions and correspondence with Bell Canada, estimates of rental costs for a variety of channel configurations suitable for use in the "Wired Scientific City" have been obtained. These costs are summarized in this Appendix, in Tables A-1 and A-2. The costs shown in Table A-1 are for a variety of video channel configurations, as given in the table. Table A-2 presents the costs for two total cable systems, including maintenance. Copies of the appropriate correspondence are included, to show the details of the configurations.

Table A-1: Specified Channels

Configuration	Channels	Cost
1(a) 5 nodes CRC, BNR, CU, OU, NRC	2 transmit 8 receive	$9670/month
1(b) 4 nodes CRC, BNR, CU, OU	2 transmit 6 receive	$6754/month
2(a) 2 nodes CU, OU	2 transmit 2 receive	$1042/month
2(b) 2 nodes CU, OU	4 transmit 4 receive	$1814/month
2(c) 2 nodes CU, St. Pats	2 transmit 2 receive	$1294/month
3(a) 2 nodes BNR, CU	4 transmit 4 receive	$5414/month
3(b) 2 nodes BNR, OU	4 transmit 4 receive	$4714/month

Table A-2: Total Cable Systems

Configuration	Cost
1. 5 nodes CRC, BNR, CU, OU, NRC	$12,500/month
2. 5 nodes CRC, BNR, CU, OU, DOC	$ 8,700/month

20 August 1971

Mr. Ross Cruikshank
General Manager,
Central Area,
Bell Canada,
78 O'Connor Street,
Ottawa, Ontario.

Dear Sir,

In connection with Department of Communications Research Contract OlG.R.36100 1-0096 we require cost information on a number of proposed video circuits in the Ottawa area. We would appreciate receiving estimates of the cost of providing video channels (6 MHz baseband), and accompanying high quality (5 kHz) voice circuits, as outlined in the following specifications:

Configuration 1

1 (a) A five-node network, with nodes at
  i) the Communications Research Centre
  ii) Bell-Northern Research
  iii) Carleton University, Engineering Building
  iv) Ottawa University, Engineering Building
  v) the National Research Council, Division of Radio and Electrical Engineering

with 2 channels originating at each node and all other channels (8) available at each node.

1 (b) A four-node network, with nodes at
  i) the Communications Research Centre
  ii) Bell-Northern Research
  iii) Carleton University, Engineering Building
  iv) Ottawa University, Engineering Building

with 2 channels originating at each node, and all others (6) available at each node.

The projected duration of the service would be two years.

. . /2

Configuration 2

2 (a) Two two-way channels between Carleton University, Engineering Building and Ottawa University, Engineering Building.

2(b) Four two-way channels between Carleton University and Ottawa University.

2 (c) Two two-way channels between Carleton University and St. Patrick's College.

The projected duration of this service would be either two or five years.

Configuration 3

Four two-way channels between Bell-Northern Research and either Carleton or Ottawa Universities. This service to have a projected duration of two years.

If at all possible, we would be most grateful for this information before September 30th. Unfortunately, if it is received much past this date it will be of little value to us.

Yours very truly,

Donald A. George
Professor of Engineering.

DAG:lom

Bell Canada

Place Bell Canada
Ottawa, Ontario
K1G 3J4
Telephone 613 239-5525
TWX 610 562-1926

R. M. Cruikshank, P. Eng.
General Manager

September 28, 1971.

Mr. Donald A. George,
Dean of Engineering,
McKenzie Building,
Carleton University Campus,
Ottawa, Ontario.

Dear Sir,

In reply to your letter of August 20, 1971, please find attached Appendix A containing the monthly rental charges in accordance with your Department of Communications Research Contract 01 C.R. 36100 - 1 - 0096 for audio and video facilities.

These rates include the provisioning of the specified number of channels outlined in your August letter, input equipment for each channel at the originating ends and inside wiring to a specific location at each node.

Since these monthly rates are based on today's costs and present technology, they can only be guaranteed for a three month period. Increased costs and new technology could conceivably increase or decrease these rates from those quoted in Appendix "A".

The time interval between receipt of a firm order and the completion of this system would be approximately six to nine months.

A two year minimum contractual interval is applicable to each of these circuits.

Should further information or details be required, please contact M. R. Levesque at 239-5904.

General Manager, C.A.

APPENDIX "A"

Configuration 1A	$9,670.00 monthly
Configuration 1B	$6,754.00 monthly
Configuration 2A	$1,042.00 monthly
Configuration 2B	$1,814.00 monthly
Configuration 2C	$1,294.00 monthly
Configuration 3A	$5,414.00 monthly
Configuration 3B	$4,714.00 monthly

30 September 1971

Mr. M.R. Levesque
Sales Manager,
Bell Canada,
Marketing Department,
43 Eccles Street,
Ottawa, Ontario

Dear Mr. Levesque,

Further to your letter of September 28th and our discussion yesterday, it would be of considerable assistance to us if you could provide a cost estimate for

(1) Configuration 1A of my letter of August 20th

(2) Configuration 1A with DOC offices in the Berger Building substituted for the National Research Council

where direct access to the coaxial cable (with amplifiers) is provided rather than the specific services quoted in your letter. It is assumed that a pair of coaxial cables will be required to effect two-way communications.

All other conditions remain unchanged.

Yours very truly,

Donald A. George
Professor of Engineering.

DAG:lom

Bell Canada
43 Eccles St.
Ottawa, Ontario

November 25, 1971

Mr. Donald A. George,
Dean of Engineering,
McKenzie Building,
Carleton University Campus,
Ottawa, Ontario.

Dear Sir:

We are pleased to provide order of magnitude rates for special coaxial cable circuitry that has the capability of video transmission, with associated audio channels, between locations stated in your letter of 30 September 1971.

We shall provide two coaxial cables including amplification. Each cable will carry transmission in one direction only.

The rates contained herein are based on these cables being used in an experimental mode for a contractual period (minimum 2 years). However, although the frequency is controlled by our amplifiers, the noise level must be within D.O.C. standards and the electrical level must be limited to protect the cables. As you can understand, these limitations are necessary to protect both our investment and service to other customers served by cables in close proximity to the coaxial cable provided for your use.

The appendix attached includes rates for the 2 configurations outlined in your September 30th, 1971 letter. These rates include flat rate maintenance however, as an alternative we would be prepared to discuss a rate which would provide maintenance on a call out basis as required rather than the flat rate. Our rates assume that you will be providing the modulation equipment during the experimental period. The system which we are offering does not provide for switching either automatic or selective.

At the conclusion of this experiment a new contract would be negotiated based on current costs and usage. If your requirements are such that they become part of a fully integrated

public system, the normal coaxial cable distribution network rates and requirements would apply as filed in our General Tarrif.

We are prepared to commence work in the spring of 1972 with a date for service in the month of October 1972, if acceptance is received in January 1972.

Yours truly,

Sales Manager Special Services
239-2650

/mw

A P P E N D I X

Experimental Wired Scientific City - Ottawa

Configuration 1A (Ottawa University, Carleton University, B.N.R., C.R.C. and N.R.C.)

Monthly rate $12,500

Configuration 1A revised (Ottawa University, Carleton University, B.N.R., C.R.C. and D.O.C.)

Monthly rate $ 8,700

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